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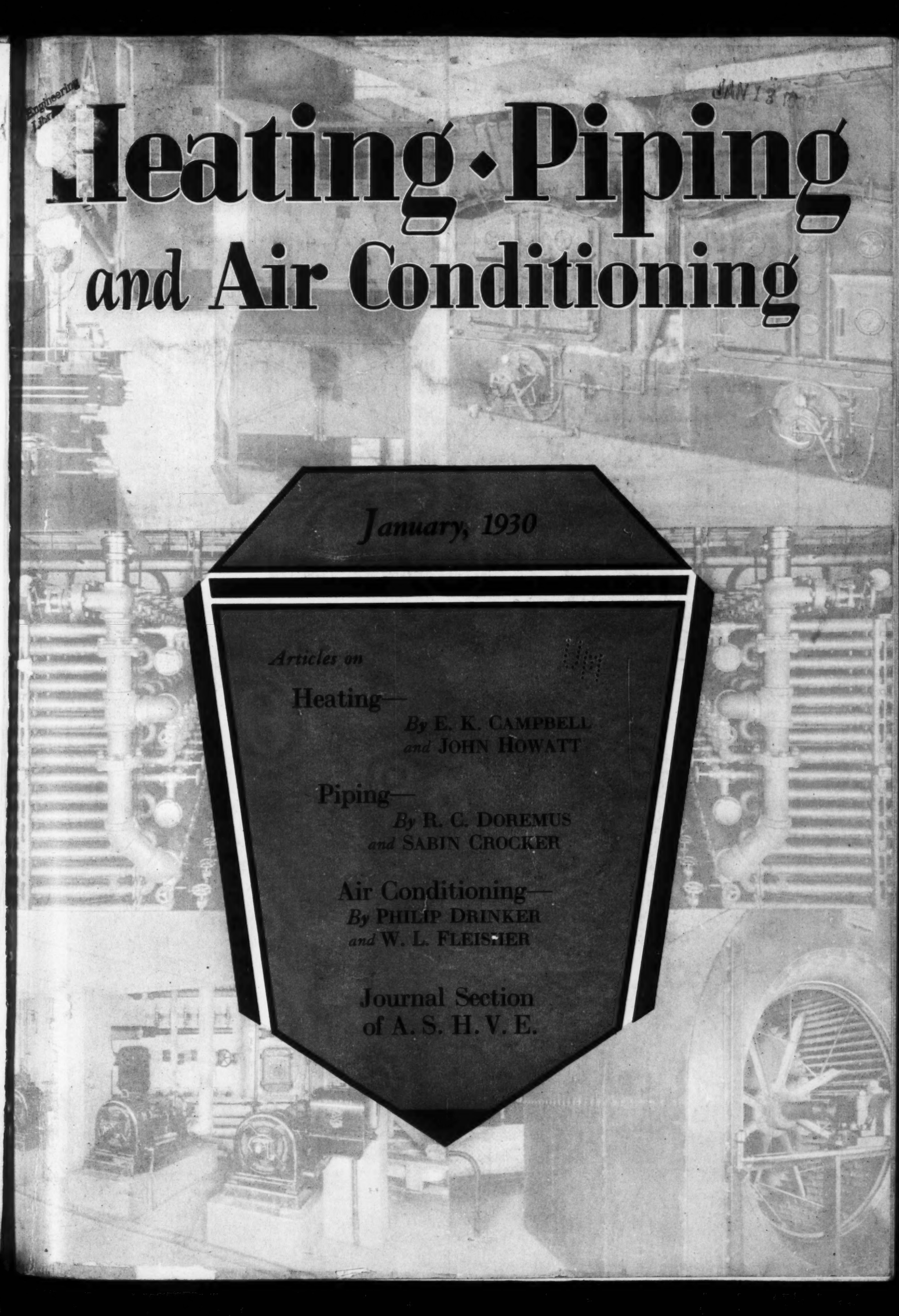
Heating · Piping and Air Conditioning



January, 1930

Articles on

Heating—
By E. K. CAMPBELL
and JOHN HOWATT

Piping—
By R. C. DOREMUS
and SABIN CROCKER

Air Conditioning—
By PHILIP DRINKER
and W. L. FLEISHER

Journal Section
of A. S. H. V. E.

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BLOWERS
AIR WASHERS
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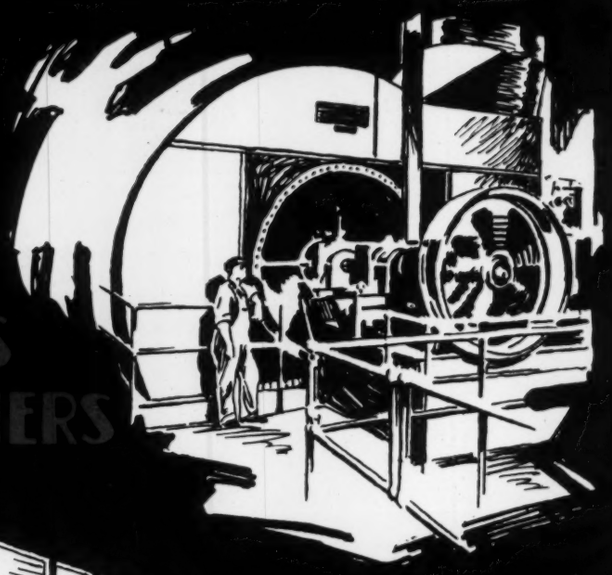

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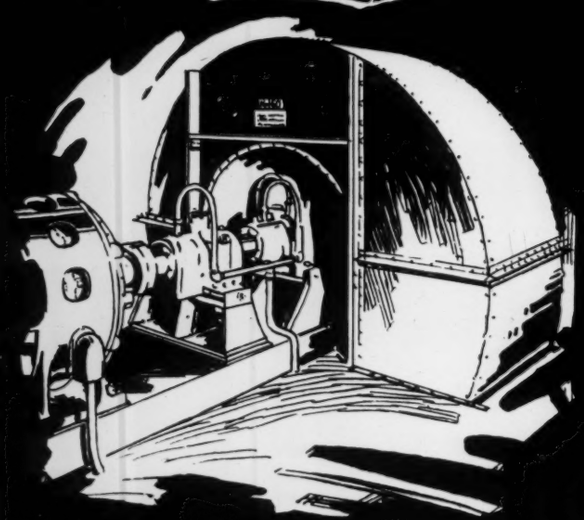

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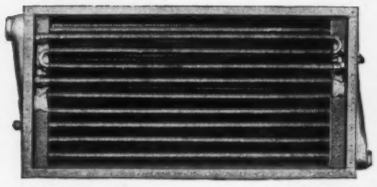

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The EDITOR'S PAGE

Heating · Piping and Air Conditioning

Dust in Industry

Industrial dust presents a problem to the modern engineer which cannot be disregarded. As pointed out in an editorial in this issue, breathing of dust is extremely dangerous to human beings.

Philip Drinker, of the Department of Ventilation and Illumination, School of Public Health, Harvard University, is one of the outstanding authorities on dust today. His article on the "Hygienic Aspects of the Industrial Dust Problem," appearing in this number of HEATING, PIPING AND AIR CONDITIONING discusses dusts due to various industrial processes and reviews the research work done at Harvard.

The subject of dust elimination is commanding not only wide engineering interest but is coming more and more to the attention of the general public. A recent issue of *Harper's* contained a paper on the effects and quantity of outdoor dust in cities, and referred to the dust measurements made by Howard C. Murphy, a member of our Board of Consulting and Contributing Editors. Mr. Murphy wrote on this subject in the July HEATING, PIPING AND AIR CONDITIONING.

A Representative Comment

We quote from a letter received from a subscriber some days ago. Our correspondent's opinion is representative of many received lately by our editorial staff.

"Quite some time ago I ordered your magazine sent to me. You will remember, perhaps, that I did not fill out the first invitation blank, as I doubted the value of your publication to me. However, since receiving and reading, with a great deal of interest, the several copies you have sent, I have been obliged to change my opinion.

"I now believe that HEATING, PIPING AND AIR CONDITIONING, besides being the most interesting, is also the most valuable publication I take."

HEATING, PIPING AND AIR CONDITIONING has kept its promise to those who subscribed before the first issue appeared. It has kept its implied promise to those who based their decision on the quality of the first two or three issues. It will maintain the high standards established.

HEATING, PIPING AND AIR CONDITIONING STARTS THE NEW YEAR

Most of us have had time by now to break any New Year's resolutions we were optimistic enough to make during the closing days of 1929. HEATING, PIPING AND AIR CONDITIONING, as a technical magazine of the highest type, however, succeeded so well in following out its self-established program for its first volume (the last eight months of the old year) that it will, no doubt, continue to accomplish its aims during the first year of this new decade.

Editorial material will continue to be of the same quality; articles will be published only after careful consideration of what our readers want. Not the least important question to be considered is the presentation of engineering information; it must be attractive. HEATING, PIPING AND AIR CONDITIONING has made the reading of technical articles a pleasure. It will continue to do so.

Our list of articles to be published during 1930 includes papers from practically all of the outstanding men in the air conditioning, heating and piping fields. Many more are in our project file. HEATING, PIPING AND AIR CONDITIONING will, in Volume II as it has in Volume I, represent the best engineering thought in the heating, piping and air conditioning fields.

A Refrigerated Room

"Piping a Refrigerated Room," the lead-off article this month, contains a set of calculations for computing the amount of pipe surface necessary to maintain the proper temperature in a cold storage room. R. C. Doremus, author of the paper, presents two pipe ratio charts, one for use with the direct system and the other for computing the piping with a brine refrigeration system.

Warm Air Heating

Warm Air and Large Buildings is the title of E. K. Campbell's paper in this number of HEATING, PIPING AND AIR CONDITIONING. In his article, Mr. Campbell stresses the question of air movement, and illustrates his points by taking up several installations with which he is familiar. The descriptions of a gymnasium, a church, a cotton mill, and a field house installation contain a wealth of material for the engineer doing warm air work.

Complete tests were run on what we believe to be the largest space in the world heated by warm air—the Butler Field House. The results of the tests are presented with this article.

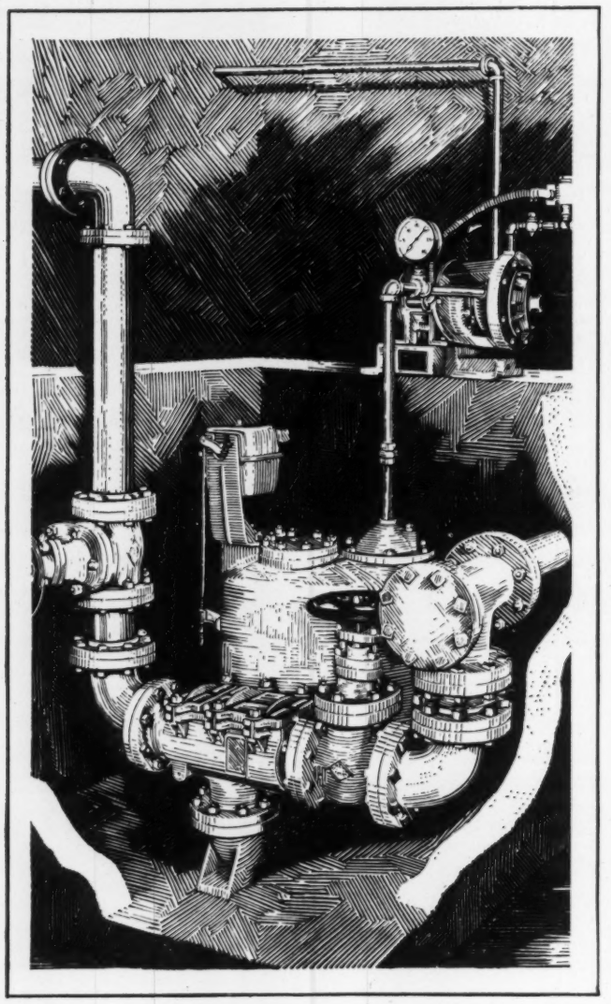
Drying Out Large Buildings

In Chicago and other cities, schools, which are heated by warm air under fan pressure, use the fans and the warm air for temporary heat during construction.

A new method in which the products of combustion from the coke fire are diluted with outside air which is passed around the furnace, the mixture being forced into the room, is described in "Drying and Temporary Heating of Large Buildings," by John Howatt, chief engineer, bureau of operative engineering, board of education of Chicago.

In addition to the equipment described in the article there are available, of course, many makes of non-patented warm air furnaces with fans called direct-fired unit heaters, which can be used in buildings for temporary heat.

There is a continual demand for elimination of delays in building construction, and in his article Mr. Howatt explains the fundamental principles of drying of buildings, which would need to be considered no matter what the method of operation. The elimination of the seasonal factor is an important question in almost every industry, as in so doing, overhead is reduced tremendously. In order to make the erection of buildings a year-'round proposition, temporary heating to dry out the plaster and provide satisfactory conditions for the contractors' men is essential.



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Heating · Piping and Air Conditioning

Vol. II *January, 1930* **No. 1**

Piping a Refrigerated Room

By R. C. Doremus

THERE are a number of factors affecting the piping of a room to be refrigerated, such as size, shape, insulation value, exposure, temperature desired, goods to be stored, air movement (whether by gravity or forced circulation), term of storage, openings and the rate of their being opened, etc. It is practically impossible, therefore, to lay down a set of rules or a "cure-all" that will apply as a standard or criterion to all cases equally well. It will be the purpose of this discussion rather to outline some of the determining factors and rules followed in common commercial practice, which, after all, are often more interesting than pure theory.

In the case of any room to be refrigerated, the first consideration is the magnitude of the problem. How much is the heat load? Once this is determined, our problem is more than half solved and it only remains necessary to use a sufficient amount of refrigerating surface to handle the load.

In order to illustrate the method of solution of such a problem, let us assume a typical room 32 feet wide by 80 feet long by 12 feet high that is insulated with corkboard on all walls, ceiling and floor. The floor is an 8½-in. concrete slab insulated on top with 4 in. of pure corkboard with a 2-in. cement topping, and exposed below to the temperature of a dry storage and shipping room. The walls of the room are composed of 13-in. brick insulated with 4-in. pure corkboard laid up in hot asphalt and, being the exterior walls of the building, are exposed outside to weather temperature. The ceiling is a 5-in. reinforced concrete slab on which the insulation of 5 in. pure corkboard is laid in hot asphalt and finally roofed over with a commercial built-up roofing. It is desired to maintain a temperature of 34 deg. fahr. for the storage of apples. The room also contains twelve 40-watt lamps and one circulating fan driven by a one horsepower motor.

Three Factors of Heat Gain

The heat conducted through the insulation envelope of walls, floor and ceiling depends upon three factors, viz:

(1) Constant of heat transfer in B.t.u. per hour; (2) total area and (3) temperature differential between the two sides of the wall or envelope. The total heat is expressed as the product of these three in the familiar heat transfer formula:

$$H = K \times A \times (T_1 - T_2) \qquad (1)^*$$

The data cover the area and temperature difference but the heat transfer constant to be used will vary with different types of construction, and must be computed or determined by reference to data tables on the subject.

Heat transfer constants are determined from data tables of conductivities of heat through these construction and insulation materials, as follows:

$$K = \frac{1}{\frac{1}{K_1} + \frac{X_1}{C_1} + \frac{X_2}{C_2} + \frac{1}{K_2}} \qquad (2)^*$$

K_w for walls:

$$K_w = \frac{1}{\frac{1}{1.4} + \frac{13}{3.5} + \frac{4}{.308} + \frac{1}{4.2}}$$

$= .0569$ B.t.u. per sq. ft. per hr. per degree temp. diff.

K_f for floor:

$$K_f = \frac{1}{\frac{1}{1.3} + \frac{10.5}{5.2} + \frac{4}{.308} + \frac{1}{3.9}}$$

$= .0625$ B.t.u. per sq. ft. per hr. per degree temp. diff.

K_c for ceiling:

$$K_c = \frac{1}{\frac{1}{1.3} + \frac{5}{5.2} + \frac{5}{.308} + \frac{1}{3.9}}$$

$= .055$ B.t.u. per sq. ft. per hr. per degree temp. diff.

*See note on page 4.

Total Heat Load

(1) Quantity of heat transferred—

Through walls:

$H = K_w \times A \times (T_1 - T_2)$

$= .0569 \times (224 \times 12) \times (90 - 34)$

$= 8565$ B.t.u. per hr.

Through floor:

$H = .0625 \times (32 \times 80) \times (80 - 34)$

$= 7680$ B.t.u. per hr.

Through ceiling:

$H = .055 \times (32 \times 80) \times (100 - 34)$

$= 9574$ B.t.u. per hr.

Total heat conducted through walls, floor and ceiling into room

$= 8565 + 7680 + 9574$

$= 25{,}819$ B.t.u. per hr.

(2) This quantity should be increased by approximately 20 per cent to allow for infiltration of air and new air admitted to room through doors, openings, etc., which is purely arbitrary on account of the variation in this quantity.

This amount for new air =

$.20 \times 25819 = 5{,}164$ B.t.u. per hr.

In the case of any room where the amount of new air to be chilled down is excessive, the heat should be calculated instead of estimated as above but for the ordinary case this method is sufficient to cover this item.

(3) Heat equivalent of electric lights

$12 \times 40 = 480$ watts

$= 480$ joules of heat

$H = 480 \times 3.412 = 1638$ B.t.u. per hr.

(4) Heat equivalent of 1 hp. fan motor.

Input is approximately 2 hp. and all is converted into heat in room—

$$H = \frac{2 \times 33000 \times 60}{778}$$

$= 5090$ B.t.u. per hr.

(5) Heat equivalent of employes:

2 porters at work stacking barrels in room—

$H = 2 \times 500 = 1000$ B.t.u. per hr.

(6) Heat from goods stored:

The apples also will add a heat load to the room depending upon whether this storage is a producers' storage or a consumers' storage. If it is a producers' storage, the apples will be put in storage from an outside temperature of 75 deg. fahr. and must be chilled down to the room temperature. If it is a consumers' storage, the apples will arrive in refrigerator cars at a temperature of approximately 48 deg. fahr.

1 apple barrel measures 19 in. diam. $\times$ 28½ in. high.

1 apple barrel weighs 160 lb., or 30 lb. per cu ft.

Specific heat = .80.

Assume room volume is 30 per cent full of apples:

Volume of room $= 32 \times 80 \times 12 = 30{,}720$ cu. ft.

Wt. of apples $= 30720 \times .30 \times 30$

$= 276{,}480$ lbs. stored.

Heat removed in chilling from car temp. to room temp.:

$H = \text{Wt.} \times \text{Sp. Ht.} \times (T_1 - T_2)$ (3)

$= 276{,}480 \times .80 \times (48 - 34)$

$= 3{,}096{,}576$ B.t.u.

This heat load is not added suddenly but will be spread over five days' time, including the actual time taken in filling the room and the time taken in the chilling process down to the room temp. of 34 deg. fahr.

$$H = \frac{3{,}096{,}576}{5 \times 24} = 24{,}971 \text{ B.t.u. per hr.}$$

Note: In the case of a producers' storage, the apples are chilled over a larger range in temperature in two weeks, which brings the rate in B.t.u. per hour approximately the same.

(7) The total heat entering this cooler is summarized as follows:

		B.t.u. per hr.
(1)	Room radiation and convection	25,819
(2)	Air changes	5,164
(3)	Electric lights	1,638
(4)	Fan motor	5,090
(5)	Operators	1,000
(6)	Goods stored (1728 Bbls.)	24,971
(7)	Total =	63,682

$$\text{Tons rating} = \frac{63{,}682}{12{,}000} = 5.30 \text{ tons refrigeration.}$$

Assuming that brine system is used and a continuous circulation of brine maintained, the refrigerating load represented by this rate of heat transfer will be accomplished by a surface made up of piping and computed by the same formula as follows:

$H = K_p \times A \times (T_1 - T_2)$ (4)

Room Temp. = 34 deg.

Mean brine temp. = 12 deg.

$T_1 - T_2 = 34 - 12 = 22$ deg.

$K_p = 2.0$ with no fan circulation.

$= 2.5$ with fan circulation.

$63{,}682 = 2.0 \times A \times 22$

$$A = \frac{63{,}682}{2 \times 22} = 1447 \text{ sq. ft.}$$

$= 2316$ lin. ft. of 2-in. pipe

$= 3340$ lin. ft. of 1¼-in. pipe

$\frac{30720}{2316}$ = ratio 13.3:1 (2-in. pipe)

$\frac{30720}{340}$ = ratio 9.2:1 (1¼-in. pipe)

Observations

It will be seen from the "total heat" (7) given above, that the principal items involved are the room loss and the heat in the goods stored. Also, that the total quantity of pipe coil surface will be used during the chilling process and once the goods are chilled to the room temperature, approximately one-half of the coils can be shut off and the other half used to take care of all losses. The total quantity of pipe calculated must be installed, however, to make it possible to chill the goods within a reasonable time and the excess of pipe during the storage period is very good insurance of flexibility in operation, especially in case of maintenance or repairs.

Almost all of the commonly stored foods are of similar formation so far as percentage of solids and water is concerned and have similar specific heats which vary only slightly. Therefore, there are two main classes to consider in piping a room.

One class of foods and materials has a normal amount of heat and the other has an abnormal amount. For those which are normal, the size of the room is an index of the quantity of heat loss through walls, etc., into the room as well as the quantity of goods that can be stored and for these a definite pipe ratio may be set up showing number of cubic feet in volume of room to one lineal foot of pipe which will be found satisfactory. For this reason, it is common practice for designers to use a table or curve of piping ratios, as shown herewith, to establish quickly the correct quantity of piping surface to be used in any case.

Those foods, materials or processes involving abnormal amounts of heat, such as fruit ripening rooms, meat chill rooms, fermenting cellars, chocolate cooling, bakeries, etc., require more careful calculations of heat to arrive at the proper quantities of pipe that will serve in each individual case. In banana ripening rooms, the bananas when stored do not contain the heat in so many B.t.u., but their ripening generates both heat and humidity which must be taken care of by both pipe coils and ventilating systems. Cold storage temperatures are determined most advantageously for freezing points, ripening points, disease points, etc., and the rooms are therefore essentially rooms of controlled temperatures and humidities.

The usual commercial manufacturing, storage or retail plant will have rooms of various temperatures to be served by one temperature refrigerant whether it be a brine or direct expansion system. The temperature of the coldest room determines the temperature of refrigerant required and this may be several degrees colder than would otherwise suffice for the rooms of higher temperature. Accordingly, the piping ratio used in the higher temperature rooms must be increased in direct proportion to the ratio of temperature differences in the two cases for a pipe area of ten square feet with a twenty-degree gradient will transfer as much heat as twenty square feet with a ten-degree gradient.

By reference to the pipe ratio curves for brine, as shown by Fig. 2, it will be seen that the room mentioned above having a volume of approximately 30,000 cubic feet, which is to be held at a temperature of 34 deg. fahr., will require a ratio of 15:1, or a total of 2,000 lin. ft. of 2-in. pipe. Incidentally, it may be noticed, this compares favorably with the amount calculated of 2,180 lin. ft.

Let us suppose that this same plant included a sharp freezer room, measuring 32 ft. × 65 ft. × 12 ft., having a volume of 25,000 cu. ft., which room is to be held at a temperature of 0 deg. fahr. By reference to Fig. 2, the pipe ratio of this room should be 3½:1, or a total of 7150 lin. ft. of 2-in. pipe. The brine temperature for the system will be determined by the coldest room in the plant and for the 0 deg. fahr. room will have to be approximately —10 deg. average, i.e., —13 deg. supply and —7 deg. return. If we were to use the ratio of 15:1 with the 30,000 cu. ft. room with this colder brine temp., the 34 deg. room would be over-piped and much too cold. In practical operation, we would shut off the brine supply to some of the coils. Therefore, we would install less piping and the ratio would be increased in direct proportion to the temperature differences.

In other words, instead of the ratio in the 34 deg. room being 15:1, it will be:

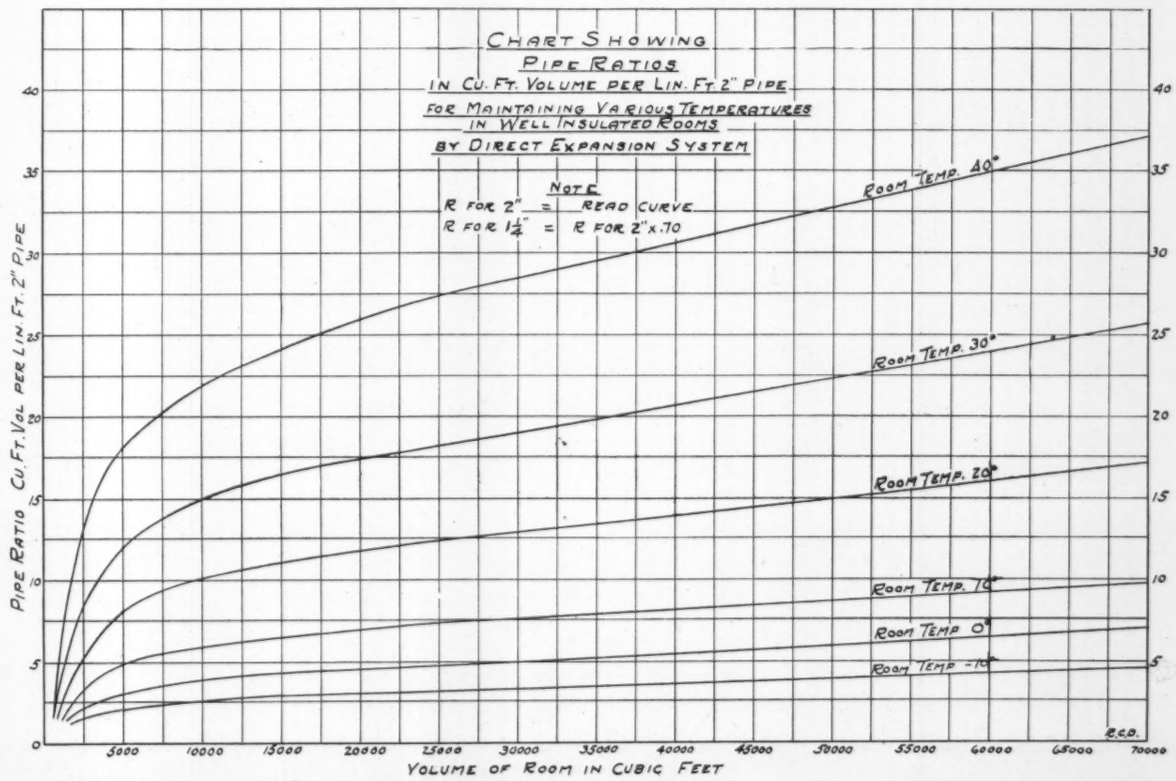


FIG. 1

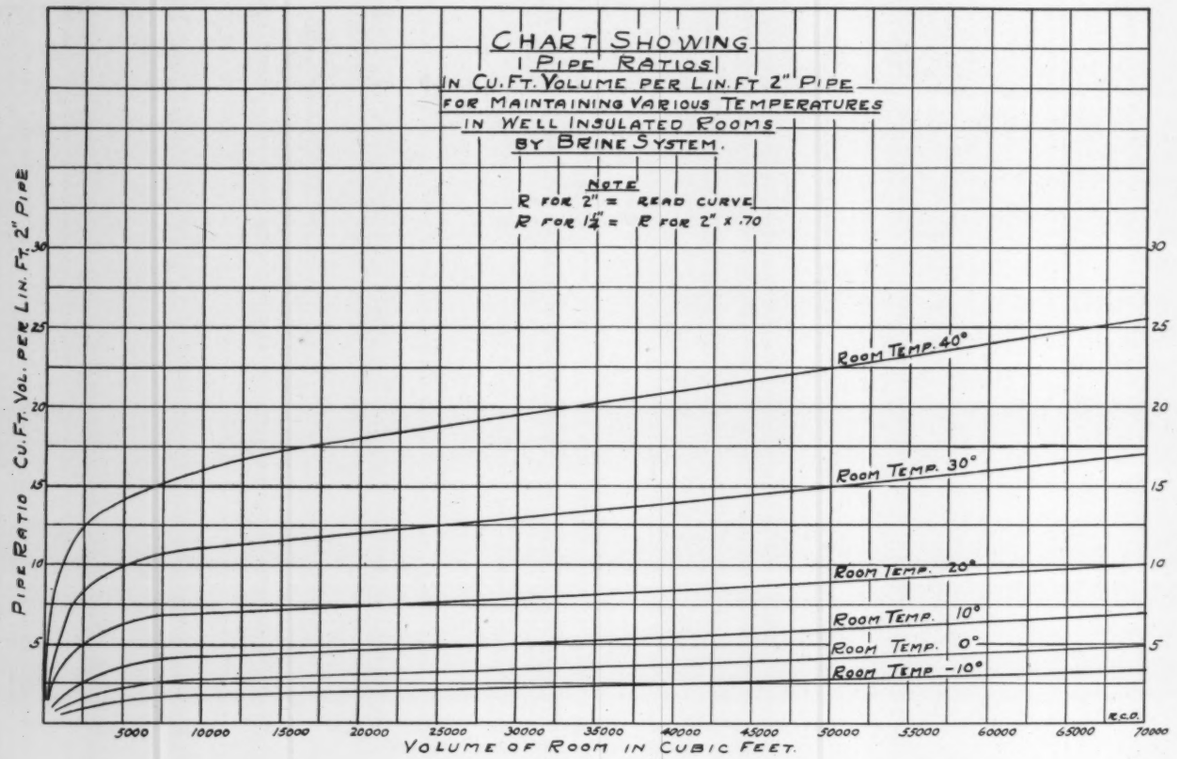


CHART SHOWING
PIPE RATIOS
IN CU. FT. VOLUME PER LIN. FT 2" PIPE
FOR MAINTAINING VARIOUS TEMPERATURES
IN WELL INSULATED ROOMS
BY BRINE SYSTEM.
NOTE
R FOR 2" = READ CURVE
R FOR 1¼" = R FOR 2" x .70
PIPE RATIO CU. FT. VOL. PER LIN. FT. 2" PIPE
ROOM TEMP. 40°
ROOM TEMP. 30°
ROOM TEMP. 20°
ROOM TEMP. 10°
ROOM TEMP. 0°
ROOM TEMP. -10°
5000 10000 15000 20000 25000 30000 35000 40000 45000 50000 55000 60000 65000 70000
VOLUME OF ROOM IN CUBIC FEET.

FIG. 2

$$R = \frac{15 \times 44}{17}$$
$$= 38.9:1$$
$$= 770 \text{ lin. ft. of 2-in. pipe}$$

for the quantity will vary inversely with the variation in temperature difference, while the ratio will vary directly.

The curves shown in Fig. 1 and Fig. 2 for direct expansion and brine systems are for 2-in. pipe inasmuch as this size is most commonly used. However, if it is desired to use a different size of pipe, the ratio should be multiplied by constants, as follows:

R for 2 in. = as shown on curves.
R for 1½ in. = R for 2 in. × .80
R for 1¼ in. = R for 2 in. × .70
R for 1 in. = R for 2 in. × .55
R for ¾ in. = R for 2 in. × .44

Now, if for any reason we are able to change the value of the heat transfer constant K_p, by higher air velocities, the ratio R will change in direct proportion. For example, if the piping is installed in a bunker room with a fan and duct system the constant K_p may be increased from 2½ to 4 B.t.u. per sq. ft. per degree temp. difference. In such an event, the new pipe ratio used would be:

$$R \text{ for bunker} = R \text{ for 2 in.} \times \frac{4}{2\frac{1}{2}}$$

which will give an increase in the ratio of 60 per cent and a decrease of 37½ per cent in the surface or quantity of pipe used. Such an arrangement is frequently used in an egg storage on account of (1) ventilation, (2) eliminating freezing of eggs by stacking too close to pipe, (3) ability to store crates higher, (4) ease in watering the eggs to prevent shrinkage, (5) better isolation for defrosting pipes and (6) makes it possible to vent defrosting odors to the outside so that the eggs will not become tainted.

Conclusion

The piping ratios given herein may vary slightly from those used by some companies, but are a fair average of those used in common practice for storage of goods having normal heat in well-insulated rooms. The proper ratio should be calculated instead of being read from a curve for any cases of poorly insulated rooms or goods giving abnormal amounts of heat. Larger ratios giving less surface may be used and frequently are proposed in cases of competition, but with less surface, a greater temperature difference must be used which requires a colder refrigerant. The owner will therefore pay in higher operating costs where he has saved on the initial capital investment at the time of installation. It is more economical in the long run to use the proper piping ratio which will maintain the desired room temperature with a reasonable temperature differential than to disregard such ratios found proper in common practice in an endeavor to cheapen the first cost.

Note: H = total heat units in B.t.u. per hour; K = constant of heat transfer expressed in B.t.u. per sq. ft. per degree temperature difference per hour; A = total area in sq. ft.; T_1 = higher temperature in degrees F.; T_2 = lower temperature in degrees F.; K_1 = convection constant for outside wall surface; X_1 = thickness of construction material in inches; X_2 = thickness of insulation material in inches; C_1 = constant of thermal conductivity of construction material in B.t.u. per hour per sq. ft. per degree temperature difference, per inch thickness; C_2 = constant of thermal conductivity of insulation material in B.t.u. per hour per sq. ft. per degree temperature difference, per inch thickness; K_2 = convection constant for inside wall surface.

Hygienic Aspects of the Industrial Dust Problem

By Philip Drinker*

IT IS well known that the breathing of certain types of dusts is harmful. Whether or not harmful effects result, depends largely upon the chemical and physical nature of the dust particles, their concentration in the air, the length of time they are breathed, and, finally, the general working conditions to which the individual is exposed. Over these factors the engineer has some control. He may be able to improve the air conditioning of the plant or to change the process enough to remove the hazard. Although he is not directly concerned with the physical condition of the workmen, he may very well be called upon to co-operate with the physician in reducing the severity of any job. Moreover the easing of the job itself will mean that the workman breathes less air per day and hence inhales less dust.

Since there are comparatively few common industrial dusts which cannot be tolerated in slight amounts, it is the duty of the air conditioning engineer to improve conditions as far as he is able and then to judge, by means of routine physical examination of the workers, whether a safe level has been reached. The frequency of such examinations will depend entirely upon the working conditions. The physician and the engineer, through preventive work, often can forestall heavy expenditures for compensation where hazards from lead poisoning, silicosis, and the like exist.

The Importance of Particle Size and of the Chemical Composition of the Dusts Breathed

In industrial health problems, we are concerned chiefly with very small dust particles,—small enough to be carried about in the air, to pass through the tortuous passages of the nose and throat, and, finally, to penetrate into the tiny moist passages leading to the depths of the lungs,—the alveoli. The chemical composition of the dusts is also of primary importance. Marble dust can be breathed in large amounts with little or no significant effect, whereas granite dust breathed in like amounts may be distinctly dangerous. There is probably no greater dust or fume hazard in industry than that encountered in mining and smelting ores of mercury and therefore extreme precautionary measures are necessary in those processes.

Particles as large as 25 to 30 microns[1] in size will usually settle out quite promptly and there is, therefore, little likelihood of their being breathed in quantity. Particles of this order are, however, responsible for producing hay fever (Fig. 1) and in industry the inhalation of wood dust from sanding machines occasionally produces a type of asthma analogous to hay fever. These particles need not reach the depths of the lungs in order to do their damage.

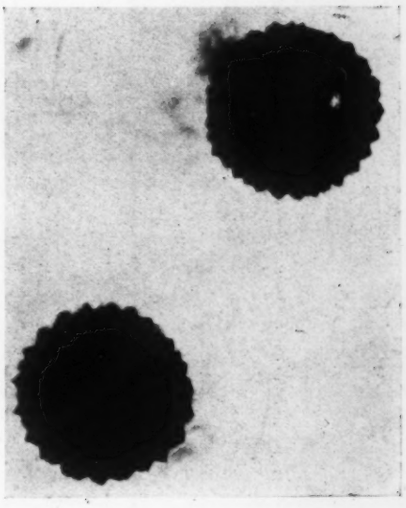


FIG. 1—POLLEN OF GIANT RAGWEED (*Ambrosia trifida*), A COMMON HAY FEVER PRODUCING POLLEN. PARTICLES SHOWN ARE 18 MICRONS IN DIAMETER. X 1500

In Fig. 2, three common and representative sizes of finely ground marble dust are shown. The 2½-micron particles are small enough to reach the alveolar spaces; in moderate concentrations they could be inhaled and exhaled without one's being aware of their presence. The 15-micron size is too large to reach the depths of the lungs and will be trapped, probably in the upper respiratory passages. The 62-micron size is large enough to be caught on the standard laboratory sieves but too large to remain suspended in moderate air currents.

In practice, the coarse and fine particles are inhaled together,—the coarse particles and some of the fine are caught in the nose, mouth, and throat and are discharged by blowing one's nose or coughing, or are swallowed. The fine particles only reach the alveoli of the lungs. If the dust contains a toxic substance like lead, poisoning can take place either in the upper respiratory or in the intestinal tract, but of the two, the respiratory route is generally the more important.

Of the particles which reach the alveolar area, those which tend to lodge there and are carried off with difficulty have especial interest for us. For reasons which are not yet entirely understood, these fine dust particles (from approximately 0.5 to 6 microns in size) seem to be harmful in proportion to the amount of free, acid-insoluble, crystalline silica (quartz) which they contain. Pure, finely-divided quartz dust breathed in sufficient concentrations daily for a number of years generally produces in the victim a disease known as silicosis. The lungs become embedded

* Department of Ventilation and Illumination, Harvard School of Public Health.

[1] A micron is 1/1,000 of one millimeter or approximately 1/25,000 of one inch.

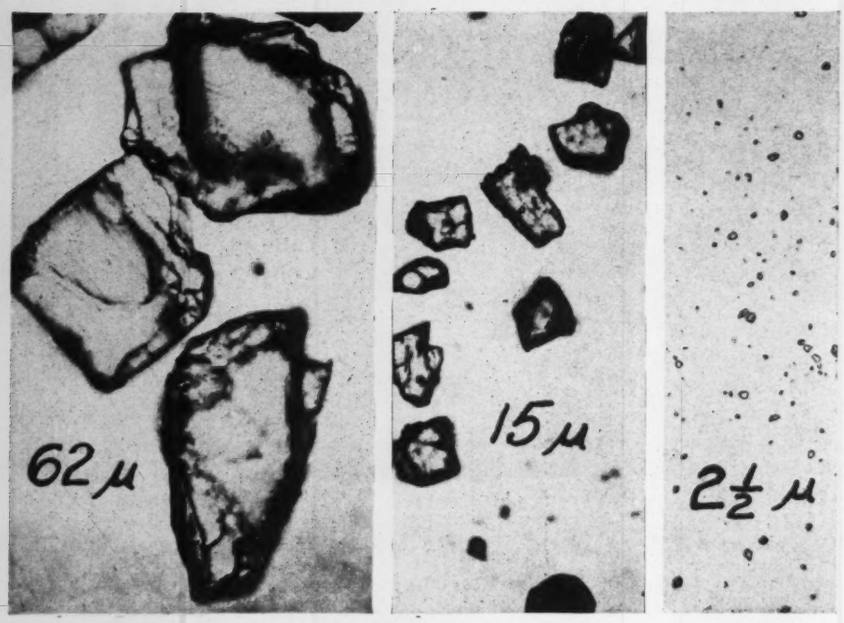


FIG. 2—PARTICLES OF MARBLE DUST SEPARATED INTO DIFFERENT GROUPS ACCORDING TO SIZE BY REPEATED SETTLINGS IN WATER. X 500

with silica dust particles, identifiable at autopsy, the effective lung area is reduced, and the victim is likely to succumb to a particularly virulent type of tuberculosis. It is an interesting fact that amounts of fine silica which would be dangerous if breathed can be taken by mouth without producing any effect whatever.

Brass Foundries

In the pouring of brass, dense white clouds consisting principally of zinc oxide are evolved. If the founder breathes these fumes as he bends over the pot to pour the brass, he may, some six to ten hours later, suffer an unpleasant attack of chills and fever, indicated by a considerable rise in body temperature, and the next day feel decidedly the worse for wear. In this instance, the particles of zinc oxide are of the order of 0.2 to 0.5 micron (Fig. 3). As in the case of silica, equal doses taken by mouth will not produce the slightest effect. Other inert, relatively non-toxic metals vaporized and burned (oxidized) in a similar manner were found to produce similar reactions when inhaled. We found this to be true, for example, of so physiologically harmless a powder as magnesium oxide, when breathed in sufficient concentrations. With the present rapid progress in high temperature welding, it is probable that other metal oxides like aluminum, chromium, and iron will be found to produce the same type of reaction.

Spray Painting

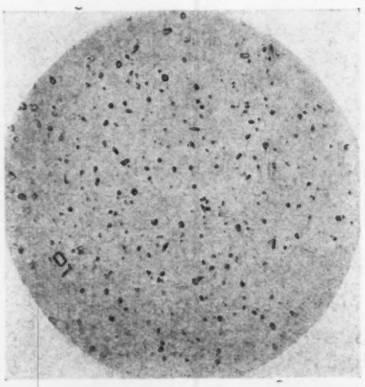
The rapid adoption of spray-painting methods in industry has introduced a comparatively new but well-recognized hazard. The vapors formed by evaporation of the lacquer may be toxic, as well as the lacquer pigments themselves, the toxicity depending, of course, upon their chemical composition. In order that the lacquer may have high spreading or covering power, the pigments must be extremely fine,—generally well below the 6-micron limit, and therefore capable of penetrating into the depths of the lungs.

Percentage of Dust Retained

We are interested not only in the nature of the dusts breathed, their concentration in the air, and the length of exposure to them; we are concerned also with the amount of dust a man retains and the amount he exhales again when he is breathing dusty air. In order to determine this proportion, we carried on a series of experiments in our large gas-tight cabinet, the procedure being somewhat as follows: Let us assume that a suspension of zinc oxide is contained in the air of the cabinet and that we know that this suspension is gradually clearing up, by settlement, according to the settling curve in Fig. 4. The subject, a normal man or woman, sits outside the cabinet, breathes the air from within through a mask, and exhales into a device which catches all the dust in his exhaled air. The dust-free air exhaled then passes to a large gasometer. Knowing the initial zinc oxide concentration, the amount of zinc oxide exhaled, and the exact volume of air breathed, it is easy to determine the percentage of zinc oxide exhaled. Fig. 5 shows a typical percentage retention curve for some eight different subjects. A similar type of curve is found for marble dust (Fig. 6). From these two curves, it seems reasonable to conclude that, under practical industrial conditions, about 50 per cent of the dust inhaled is retained. What proportion is retained in the depths of the lungs and what proportion in the upper respiratory passages must be estimated by indirect methods.

As a result of our experiments in inhaling zinc oxide, we found that when the subject breathed slowly and deeply, his reaction was much more severe than when he breathed rapidly and his breaths were shallow. Deep breathing brings more dust into the lungs and is, therefore, more dangerous than shallow breathing when a toxic substance is being inhaled.

FIG. 3—ZINC OXIDE FROM POT OF MOLTEN BRASS. PARTICLES ARE ABOUT 0.4 MICRON IN SIZE. X 1285



This fact concerns the engineer, because he can observe men at work, watch the rate and depths of their respirations, and change the work from heavy to light when necessary. A man lifting a

heavy weight will generally take a big breath before taking hold of the weight, hold his breath while he lifts, and then take four or five big deep breaths when he has released his hold. In our experiments, we have found that there is no better way of getting the dust particles down into the depths of the lungs than by the deep breathing caused by vigorous exercise. If work must be carried on in dusty atmospheres, therefore, it is important that such work should be light.

Preventive Measures

The most obvious, and certainly the most important, preventive measure is the captation of the dust at its source by the application of appropriately designed local exhaust hoods. Not infrequently the dust itself is of sufficient commercial importance to pay the cost of a complete dust collecting installation.

The installation of such a system is far more satisfactory than the use of any sort of protective masks or respirators, which should be regarded rather as emergency equipment, adapted to short time exposures only. These masks are never wholly effective, they are rarely kept in good condition, and the workers find them uncomfortable and irksome to wear, particularly in warm weather. The most comfortable and effective of the masks and respirators available are the so-called fresh air or hose masks, which supply the wearer with a continuous stream of clean air, delivered inside the mask at a rate and volume which he can personally control. The chief objection to their use is the fact that the wearer must remain near a source of compressed air and be connected with it by a thin rubber tube.

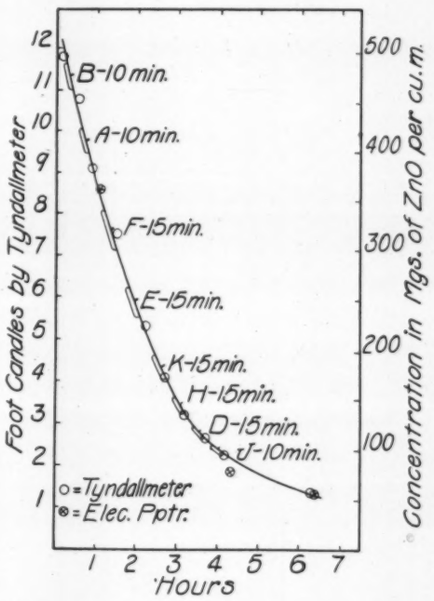


FIG. 4—INHALATION EXPERIMENTS PLOTTED ON A TYPICAL SETTLING CURVE FOR FRESHLY GENERATED ZINC OXIDE FUME. BRACKETS ON THE CURVE INDICATE THE ACTUAL TIME AND DURATION OF EACH INHALATION EXPERIMENT. THE TYNDALLMETER IS A PHOTOMETRIC DEVICE BY MEANS OF WHICH THE INTENSITY OF THE LIGHT REFLECTED FROM THE FUME PARTICLES IS MEASURED. THE CHIEF ADVANTAGE IN ITS USE IS THAT DUST ESTIMATIONS CAN BE MADE INSTANTLY

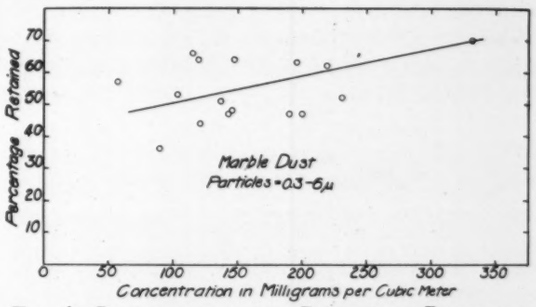
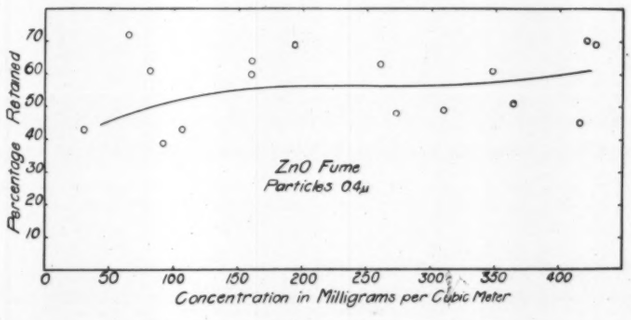


FIG. 6—CONCENTRATION AND PERCENTAGE RETENTION OF FINELY DIVIDED MARBLE DUST (MAINLY $CaCO_3$) FROM VERMONT QUARRIES

The common types of "pig snout" respirators are equipped with filters of paper, cotton plug, or sponge, their efficiency being about in the order named. The filtering efficiency of these respirators generally decreases considerably with use and workmen are likely to grow careless and wear respirators with leaky valves. Although such devices are better than no protection at all, they are in no sense a substitute for proper air conditioning in dusty trades.

The modern pneumatic rock drill and stone-cutting tool are powerful dust producers. If the driller is working in a confined area, he generally breathes dense clouds of dusts which are often of a harmful nature. A jet of atomized water, or better one of steam, directed at the point of dust generation is an effective dust catcher, but such an arrangement is often wholly impractical.

FIG. 5—CURVE SHOWING THE PERCENTAGE OF PARTICLES RETAINED BY MAN ON BREATHING VARIOUS CONCENTRATIONS OF ZINC OXIDE SUSPENDED IN AIR. SIXTEEN EXPERIMENTS VARYING FROM 4 TO 40 MINUTES EACH WERE REQUIRED TO OBTAIN THIS DATA



Settling of Fumes

Fumes like zinc oxide in brass foundries clear up with surprising rapidity if the air is stirred by fans. Fig. 7 shows the comparative settling curves of zinc oxide fume when it has been allowed to settle naturally and when settlement has been accelerated by steam jets and also by turbulent air motion. In this illustration the ordinates (foot-candles) represent concentration. Curve *B* shows the effect of air movement, which causes frequent collision between the fume particles and thus accelerates their settling out. Curve *C* shows the effect of higher relative humidity —the air of the cabinet was brought almost to the fogging point before the fume cloud was formed. In curve *E*, the air of the cabinet was at the normal dew point of the air in the building, the fume cloud was formed, and a steam jet was then turned on for a few seconds. From all three curves, it is clear that

settlement can be hastened without resort to general ventilation.

The type of dust generated by rock drills or sand blasts is not affected by turbulent air motion and the only practical remedy is adequate ventilation. In our own laboratory, we have set up an experimental granite cutting shed

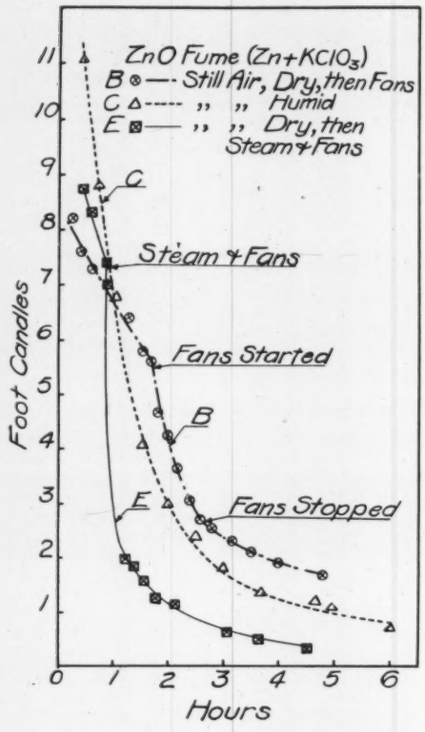


FIG. 7—SETTLEMENT CURVES OF ZINC OXIDE FUME MADE BY EXPLODING ZINC POWDER AND POTASSIUM CHLORATE IN A 1500-CUBIC FOOT GAS-TIGHT CABINET. NOTE THE EFFECTS PRODUCED BY TURBULENT AIR MOTION AND BY STEAM JETS. BOTH CAUSE THE PARTICLES TO AGGREGATE INTO UNITS LARGE ENOUGH TO SETTLE OUT

to study methods of dust control in that industry. In this work we have received the active co-operation both of the granite manufacturers and of the granite cutters' union. As the result of our studies, we have been able to design satisfactory hoods for the different tools and can determine the suctional force necessary to make granite cutting reasonably clean and safe when a professional stone cutter is performing at full speed.

Rock drilling, blasting, and sand blasting are now being carried on right in the middle of large cities. Drilling of the foundation holes for skyscrapers has become an almost separate branch of engineering. We no longer have to go to remote districts to study mining operations, —we can see them all, including compressed air work, right in our midst.

The time is not far off when it will be compulsory and profitable to protect men from breathing industrial dusts in harmful amounts. In certain countries comprehensive laws are already in effect.

Illustrations through the courtesy of the Journal of Industrial Hygiene

Air Conditioning Paper and Textiles

Trends in the Preparation of the Raw Material and the Effect they will have on Air Conditioning

By Malcolm Tomlinson

WHEN air conditioning is considered by paper and textile manufacturers today the results of recent developments and research work are bound to influence applications. Some of these new developments will be noted and discussed here in order that the present day trends, in preparing and conditioning papers and textiles, may be better understood.

In the paper field a recent investigation of the Bureau of Standards has brought out some interesting facts concerning "purified" wood and rag fibers. The data supplied are preliminary in character so that it does not seem advisable to attempt to reproduce them in tables or charts but the facts so far developed are of deep interest. Soda, sulphite, new white rag, old white rag, purified wood pulp and half stocks were investigated. Physical tests were made to determine the effect of various sizings, of heat, and of purifying the fiber. As these tests progress the scope of the research will no doubt widen to give more complete information on various fillers and on other papers in commercial use.

In the past resistance to aging and excellence of color characteristics were held to be features securable only in the best quality rag papers. In order to test this belief a heat of 212 deg. fahr. was applied for 72 hours as an accelerated aging test. Purified wood pulp and rag fibers were found to have equal ability to retain brightness and folding endurance before and after heat was applied. Rag half stocks were better than the ordinary soda and sulphite

The facts in this article have great value to air conditioning engineers who may be called upon to serve the electrical, the paper or the textile industries. In the coming demand for purity of fiber or pulp in higher grades of textiles and papers the use of conditioned air will play a large part. In some instances it may serve only to eliminate dust and dirt from the fibers and pulps and to give human comfort. In others it will be needed to vary the humidity in various steps of the manufacturing process in order to obtain, at particular times, the physical characteristics needed for best results. Again it will be eliminated, by the introduction of coatings and coverings, from some phases of manufacturing only to find a bigger field in the same industry in some other process never before served. One thing is certain—as the demand for purity and quality grow, air conditioning and drying of higher and higher order must be prepared to meet the problems which will arise.

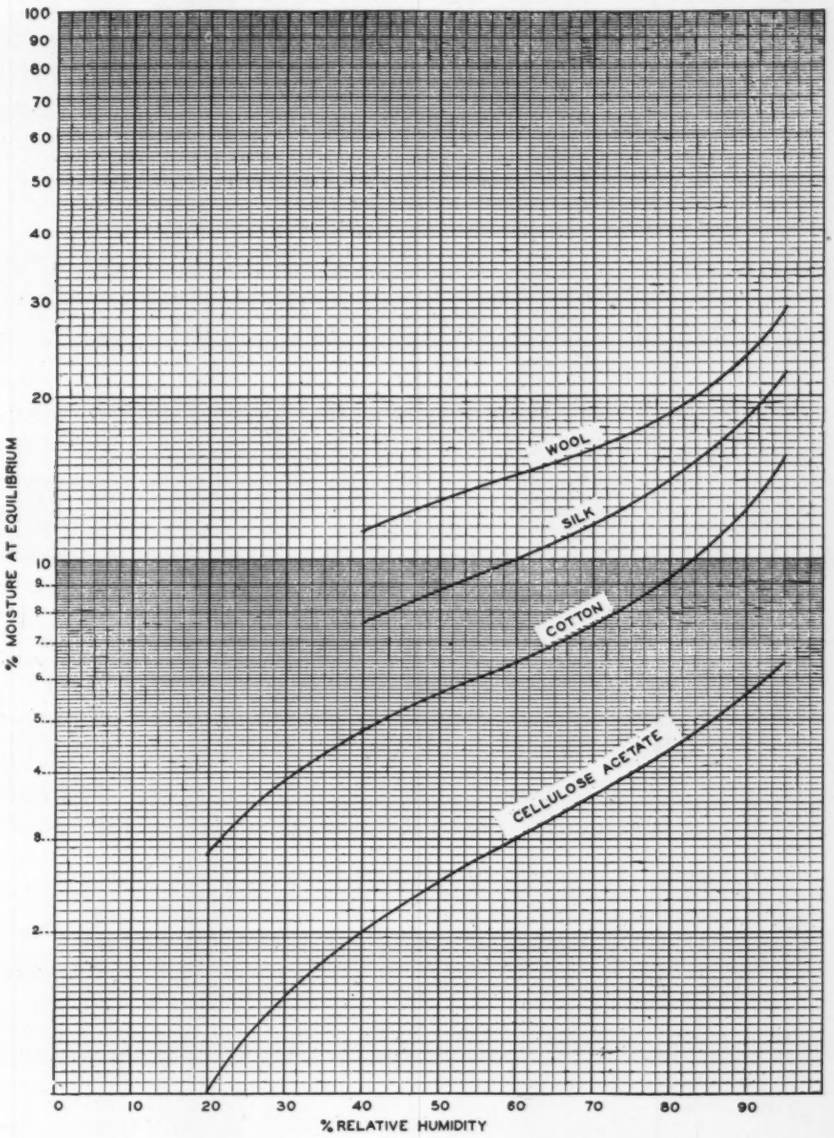


FIG. 1. TYPICAL EQUILIBRIUM CURVES FOR COTTON, SILK AND WOOL COMPARED WITH CELLULOSE ACETATE

pulps. Glue sizing was found to increase the permanence of paper but the sizing was rapidly lost on heating. Starch and rosin sizings no doubt would act in the same way.

Cellulose Acetate as Heating and Electrical Insulation

The Bell Laboratories, in the textile field, have been investigating practically the same sort of effect in the form of washing to remove soluble salts. These salts were thought to have considerable influence on fading of colors and to aid in weakening the fibers where the relative humidity was high. In Fig. 1 will be found typical equilibrium curves for cotton, silk and wool compared with cellulose acetate. When considered from a hygroscopic standpoint, the latter provides one of the very best known synthetic insulations and is being considered as a substitute for paper and textile insulations. One peculiar characteristic is worthy of note. While animal fibers absorb more water than washed or unwashed natural vegetable fibers, they provide a better insulation against heat and electrical leakage. Another peculiar property of all hygroscopic material (vegetable, mineral or animal) is the shape of the equilibrium curve. This characteristic is more evident when semi-log paper is used for plotting since with this scale relations hold true even though magnitudes vary greatly.

Elimination of Soluble Salts

When washed silk and cotton fibers were compared as to insulation resistance against the unwashed commercial fibers of the same origin and quality it was found that the elimination of the soluble salts gave very much better insulation resistance under varying conditions of higher humidities. No data was submitted to show that these same relations held for low humidities. In Fig. 2 the insulation resistance, in megohms, at 85 deg. fahr. are shown plotted against time in days and also against relative humidity. As each reading was obtained for a particular textile the relative humidity was changed so that a reading represents 24 hours of constant humidity previously applied to the fiber under test. Unwashed cotton gave such poor results that most of the data concerning its characteristics could not be plotted. It is worthy of note that, at high humidities, washed cotton was superior to unwashed silk. Superior electrical char-

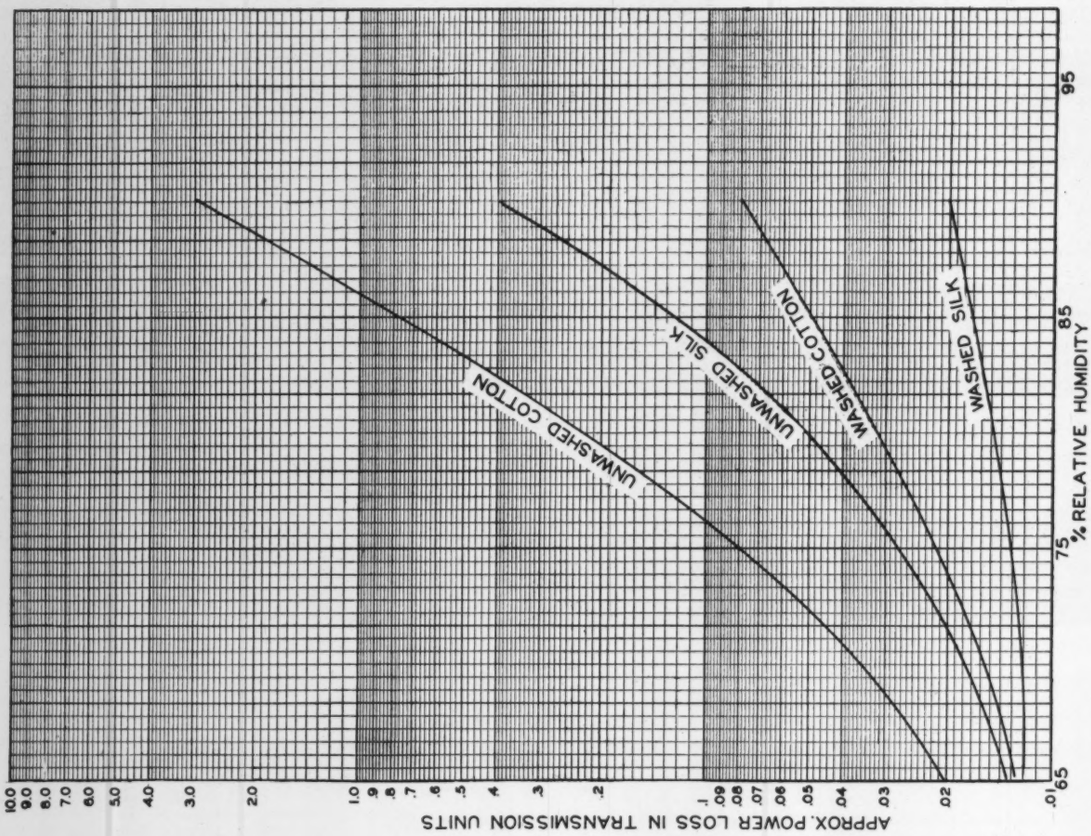


FIG. 3. APPROXIMATE POWER LOSS OF WASHED AND UNWASHED SILK AND WASHED AND UNWASHED COTTON AT VARIOUS CONDITIONS OF RELATIVE HUMIDITY

acteristics for fibers evidently depend upon purity just as superior physical characteristics in paper were found to depend upon the same quality. Is it not possible that, where purity is had, both the physical and the electrical characteristics of papers and textile fibers would be greatly improved?

Fig. 3 gives the approximate power loss, in transmission units, of washed and unwashed silk and cotton fibers under various conditions of relative humidity. From the standpoint of telephone requirements it is very evident that purity of insulation is an important factor in design.

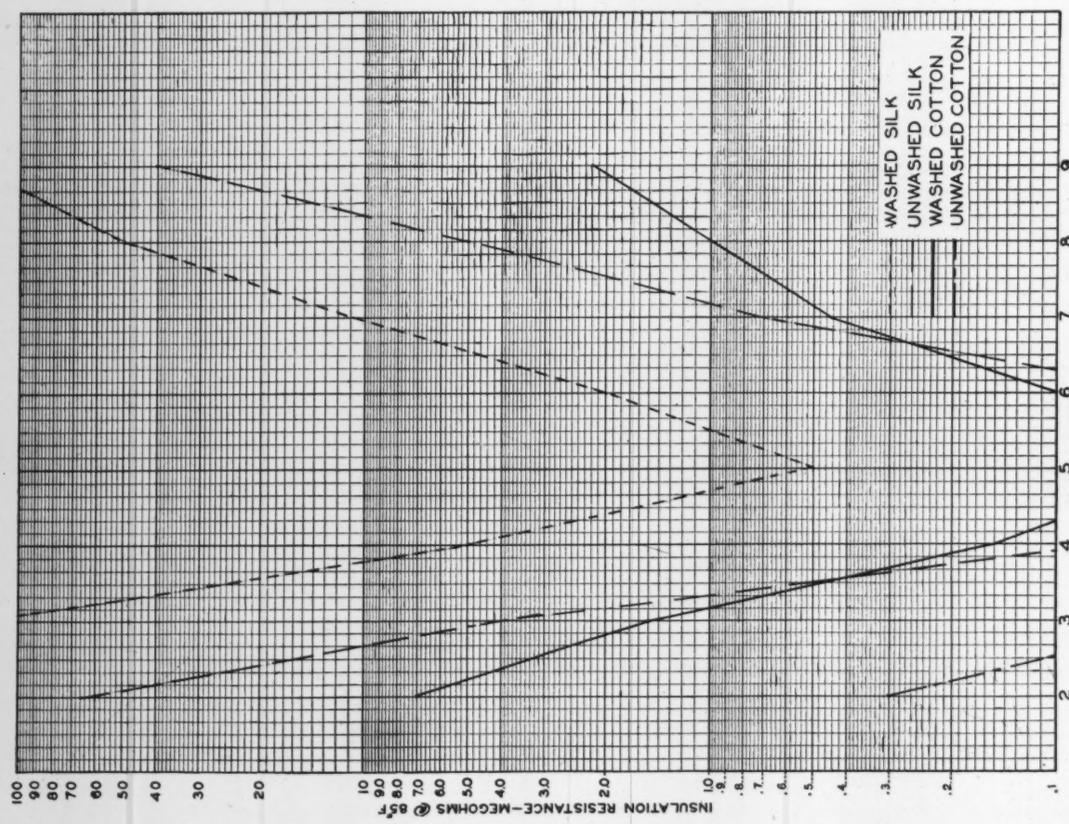


FIG. 2. THE INSULATION RESISTANCE, IN MEGOHMS, AT 85 DEG. FAHR., PLOTTED AGAINST TIME IN DAYS AND ALSO AGAINST RELATIVE HUMIDITY FOR WASHED AND UNWASHED SILK AND COTTON

Another fact one obtains from these data is the decrease in electrolysis which can be expected in d.c. cables where purified textiles are employed. These investigations, particularly those which developed the data in Fig. 3, will no doubt result in the substitution of washed cotton for unwashed silk in many applications connected with apparatus for voice or sound transmission.

Synthetic Compounds

Further investigations have been made on the use of synthetic compounds. In Fig. 1 the cellulose acetate equilibrium curve was given. Softening agents, such as the synthetic resins, reduce the brittleness and increase the gloss as well as the adhesion of cellulose acetate. Its enemies are steam, strong acids, alkali, formic and acetic acids and some organic solvents. Used as an insulation, with an outer covering which will afford protection against these enemies, it has great possibilities as a substitute for paper. Its use is likely, therefore, to increase rapidly in the entire electrical field. Other synthetic compounds also soon may find their way into both the paper and textile fiber fields as a coating or protection against moisture and as a protection against wear. If we want our materials to stand up against age it is an essential that they either be kept in a dry atmosphere or be protected against regain.

These data all go to impress one with the close relations between poor conductors of heat and good insulation against moisture. A third factor, good resistance to electrical leakage, seems bound up with these first two factors in a way that is almost weird.

Proper Control in Welding Pressure Vessels

INTENSIVE study involving all possible factors from engineering design to methods of final tests have shown that the idea of proper control in welding pressure vessels is sound. Each step of the development should be made in accordance with this plan.

Six factors of proper control are:

(a) Determining the ability and knowledge of welding operators.

(b) Selecting material for good welding quality.

(c) Correctly designing the vessel and welding joints.

(d) Properly preparing the material for welding.

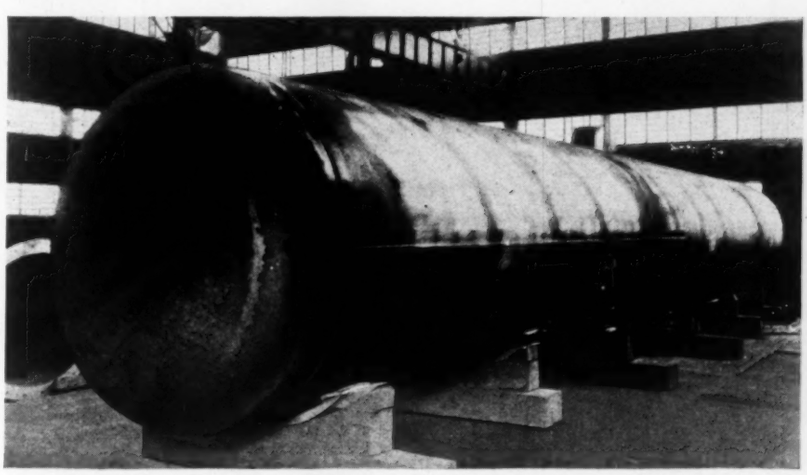
(e) Applying approved welding technique.

(f) Satisfactorily testing the completed vessel.

In reviewing the present status of pressure vessel welding it is of interest to study the effect that each of these factors has had upon the final result.

Check of Welder's Ability

Early in the work on pressure vessels, it was found that mere consideration of a welder's previous experience was an unsatisfactory and unreliable indication of his ability. Even experience on heavy plate or tank work was not conclusive, as was shown when operators were required to weld test plates from which standard tensile coupons were cut and pulled. This led to the adoption of a requirement that each operator should submit satisfactory tensile test results before being allowed to weld on pressure vessels. Even after acceptance, additional test pieces are required at intervals to insure maintenance of the same high quality of workmanship, which is essential to good welds.



Results obtained over a period of years show conclusively that this plan places the human factor under absolute control and thus eliminates an element of doubt that tended to exist in the earlier days of welding.

Qualification Test

At the present time, specifications for pressure vessels made under proper control require each welder to submit test specimens, unless the welder has successfully passed a test on similar work within six months. Whenever possible, operators considered for test should have had experience on heavy plate, preferably on welded tank construction. If the operator has not had considerable experience in making ripple welds in heavy plate by the "back hand" method as recommended for longitudinal and girth seams, he is allowed to practice until he has become thoroughly proficient before submitting test specimens. This is decided by the foreman or inspector.

Test specimens are made by welding together two plates, each 9 by 12 in., the 12-in. edges being beveled for single or double vee according to type used. Plates are of at least the same thickness as actual work. Welds should be made by the back hand method. For double-vee welds, the weld reinforcement should be at least 15 per cent of the plate thickness on each side. Single vee welds should be reinforced not less than 25 per cent of the plate thickness.

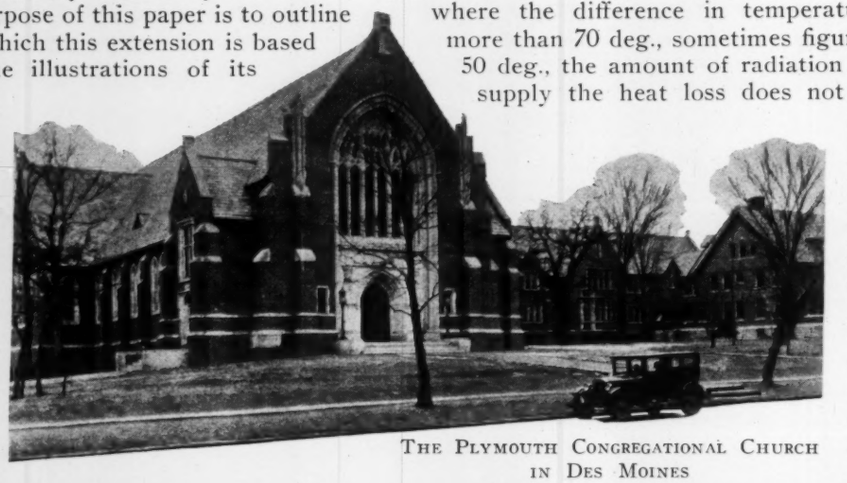
Completed test pieces are sent to an approved laboratory for test.

Warm Air and Large Buildings

By E. K. Campbell

THIS is a period when great improvements are being made in all types and kinds of heating systems. The warm air heating industry has been making great strides, improving its ideas and its installations. The work at the University of Illinois, and elsewhere, in furnace research is having a widespread effect, improving the quality of workmanship, the efficiency of design and the results given by furnace heating.

Along with this improvement in gravity furnace heating has come a great improvement in the furnace fan system. Its use has greatly extended and many large buildings are now successfully handled by the furnace fan system. The purpose of this paper is to outline the principles on which this extension is based and to show some illustrations of its adaptability and its application to large structures.



The Plymouth Congregational Church in Des Moines

Any successful extension of warm air heating to large buildings must have as its foundation just as sound and true engineering knowledge and experience as is required for the application of any heating system. That engineering knowledge should include the steam engineer's knowledge of the problems to be met.

It is also true that the warm air system can be extended much further if the engineer has a knowledge of steam engineering, and is able to combine with an air system some steam for meeting special problems or avoiding unsightly and objectionable ducts.

One of the engineering principles involved is the large volume distribution within large rooms without the use of distributing ducts.

It has been almost the universal practice in heating large rooms by air movement to run ducts over a considerable part of the area with discharges at frequent local points. The necessity of these ducts has been a handicap in many cases and has confined the use of steam blast systems to such buildings where the ducts could be provided for by the architect. The application of such systems to the heating and ventilating of audience rooms, however, has been very greatly retarded by this practice.

Of course it had its origin in the knowledge that with direct radiation it is necessary to scatter the units in order to heat all parts of the room. It has not been so clearly recognized, however, that the necessity for scattering the direct steam units is due to the small volume of air moved by the radiators. In all the experiments and tests, that have come to my knowledge, there has not been one test made to determine the volume of air moved by a radiator, when condensing one quarter pound of steam per square foot.

Importance of Air Movement

The importance of this becomes apparent in comparing high-ceilinged auditoriums in the north and south heated with steam.

In the north, where the difference in temperature is 90 or 100 deg., the amount of radiation required to supply the heat loss gives a fair air movement in proportion to the ordinary sized auditorium. In the south, where the difference in temperature is never more than 70 deg., sometimes figured as low as 50 deg., the amount of radiation necessary to supply the heat loss does not produce the same air movement. Hence, while many people think no heating is required in Alabama, there is more frequent trouble with cold floors and improperly heated auditoriums in the south than in the north. The old theory of ventilation which required 30 cubic feet per minute per person from out-of-doors has stood in the way, to some extent, of the development of a more rational system.

The extension of warm air heating to large buildings, therefore, awaited the development of a different theory of ventilation and of distribution.

Theory of Recirculation

This theory was first promulgated by A. K. Campbell, then of Newton, Iowa, in 1880 when the patent office, after three years' investigation both in this country and in Europe, granted him a patent on recirculation as applied to furnace heating. His application was largely to residence work and entirely under gravity conditions, but the idea of recirculation gradually won its way and in recent years has been established as a standard method in gravity warm air heating. The tests made at the University of Illinois to date have been based on recirculation.

It has been demonstrated that recirculation in a volume proportional to the volumetric contents of the room will distribute the heat evenly over the largest rooms. The laws governing the circulation of fluids apply equally to air and water. If the distribution of warm air within a

room is thought of the same as the distribution of warm water within a tank, the difficulties disappear and the application becomes a matter of calculation of heat loss and of experience in determining that volume which will give the desired result.

In either case the warmer fluid goes to the top and the colder remains at the bottom. In either case if the volume recirculated is not sufficient the warm fluid will lose its temperature before it reaches the bottom and the bottom of the tank or the floor of the room will not be heated. The warm fluid floats on top of the cold, until the colder fluid is drawn out or is in some way heated.

There is this great difference between heating a room and heating a tank of water. The hot water floating at the top of the tank when only part of the tank is heated can be used. But the warm air floating at the ceiling of a room when the floor is cold is of little use. It is therefore vital that in all large rooms where it is desired to have a comfortable temperature at the floor, the cold air on the floor be removed.

A Gymnasium Installation

The gymnasium of the Country Day School of Kansas City had a gravity furnace. It was a good gravity job but the volume of air in the room was too large for the volume of air handled through the furnace by gravity. It was decided that a fan be installed.

Before the fan was installed, the heat all remained in the upper part of the room. It was of no use to anyone and it was hard to tell, standing on the floor, that there was any heat in the building. With no change whatever except the increased air movement due to the fan, the heat was brought down to the floor before it lost its temperature. The floor was heated and the room made comfortable. There was also a saving in fuel.

This illustrates the fact that the extension of warm air heating to large rooms requires the use of a method which will not only move air in proportion to the volumetric content of the room, but will handle all of the air necessary to move.

The extension of the furnace fan system to large buildings also involves the development of larger units in furnace construction. This is necessary in order to hold down the number of fires to a reasonable basis.

The development of special apparatus is also necessary because plants heating large buildings operate under entirely different conditions from those governing residence heating. Many large buildings are not heated continuously and any plant designed for such a building must be capable of heating the building in two to three hours in order to satisfactorily meet the requirements. This means hard firing.

Hard firing usually involves a tremendous proportion of the heat going up the chimney unless the particular apparatus is designed to absorb that heat. Therefore a large furnace must have a proportional area of secondary surface. There must be a large volume of air striking this secondary surface before striking the prime surface in order to absorb this heat before the gases reach the chimney.

Single units have been developed and are in successful operation, producing under such firing conditions approximately 3,400,000 B.t.u. per hour per unit, with air entering the fan at about 50 deg. fahr. and a flue gas temperature of approximately 600 deg. fahr. At a capacity of 1,700,000 B.t.u., which is the normal rating, the flue gas temperature is much lower and has been known on low fires to go below 212 degrees, condensing the steam in the gases. This is undesirable.

Heating a Church

The combination of these ideas enables the furnace fan system to heat some of the largest and finest churches without disfiguring the basement with a multiplicity of ducts. A single duct or opening distributes the heat evenly over the largest auditorium. The fan in connection with the branch duct system reaches many of the small rooms. The steam used in combination makes possible reaching the balance of the small rooms and the remote and exposed points.

The Plymouth Congregational Church of Des Moines, Iowa, a long "L" shaped building, illustrates all of these ideas. It is 234 ft. long through the Sunday school axis, and 180 ft. long through the auditorium axis.

A steel boiler is set between two furnaces, each furnace having a rated capacity of 1,000,000 B.t.u. This rating is based on the furnaces having to take care of the warming up load of a cold building and the actual capacity of the furnaces on test is approximately 2,000,000 B.t.u. each. The boiler has a rated capacity of 4,000 sq. ft. and has an economizer or drum consisting of a number of tubes attached to the smoke outlet of the boiler. The boiler as well as the furnaces is subject to the air movement from the fan.

The total heat loss of the building, as normally figured, is about 2,260,000 B.t.u., but this does not include the warming-up load which might be estimated conservatively at about 50 per cent of the normal load, making a total load during the warming-up period of about 3,390,000 B.t.u.

The Butler Field House

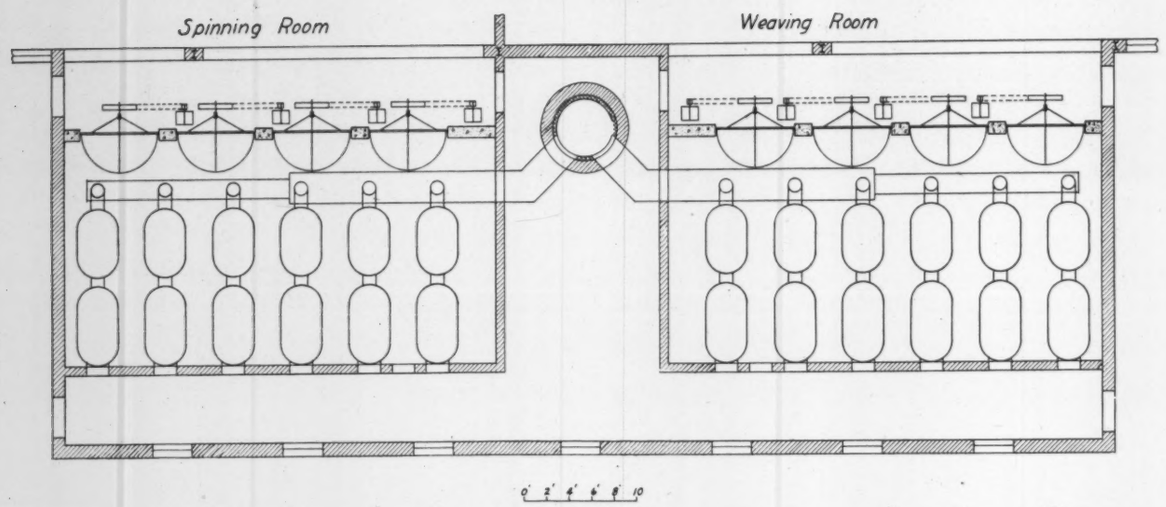


FIG. 1. FURNACE ROOM FLOOR PLAN AND CROSS-SECTION OF THE SAND SPRINGS COTTON MILL IN OKLAHOMA. THIS INSTALLATION OF WARM AIR HEATING IS NOTABLE BECAUSE OF THE LARGE FLOOR AREA AND THE HEAVY HEAT LOSS FROM THE BUILDING

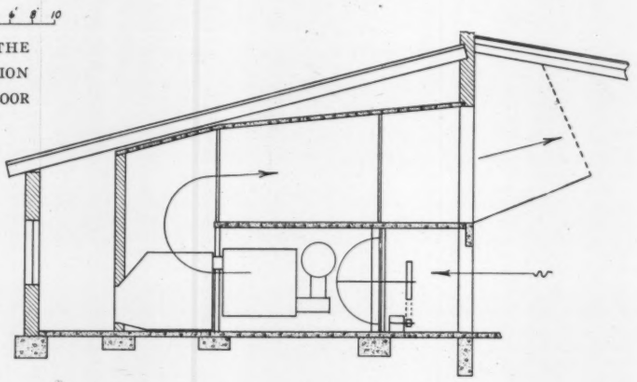
The furnace fan system takes care of the auditorium, the recreation room, the dining room, the organ loft, the halls of the Sunday school wing and some of the smaller rooms. The steam system carries the small separate rooms of the Sunday school department and the main vestibule.

The steam system was not increased to carry the warming-up load, the furnaces having the capacity to carry this load for the entire building.

The warming of the halls of the Sunday school section by the furnace fan system draws cold air from the floor of the hall as well as putting warm air into it. With the doors of the class rooms open, as they normally are during the warming-up period, the cold air on the floor of the class rooms is drawn into the hall and back to the furnaces, thus relieving the steam radiators in the class rooms of a large part of their load. In practice it has been found that the real load of the steam radiators is to raise the temperature of the room the last 10 or 15 degrees and to maintain the temperature of the room during the class period when the doors are closed.

The Auditorium

The heating of the auditorium entirely by air movement presented a special problem. The only place available for bringing in the warm air and taking out the cold air was in the end of the transept next to the Sunday school wing. Nine feet in front of the warm air openings were arches supported on stone posts and the return air for the auditorium was drawn out immediately below. If the air from the warm air opening struck these arches or posts, it meant short-circuiting and defeating the desired results in the auditorium. Two openings were therefore provided, of such size as to give the necessary total capacity, but also sized and spaced so that the air could be driven through the arches without interference and short circuiting. This particular feature of the plant caused some questioning but on test with four thermometers, one hung on the post immediately between the openings, one directly across and two at the rear of the auditorium, there was only one degree difference in the four temperatures.



This auditorium contains 275,000 cu. ft. of space, has a high Gothic ceiling, and presents a problem which is easily met by large volume circulation. The building as a whole involves about all of the problems that the heating engineer ordinarily meets.

No efficiency test was ever made on this plant. Contrary to the expectations when the building was erected, the building has never been allowed to become thoroughly cold, enough heat being maintained at all times to keep the building tempered. Under these conditions, during the winter of 1927 and 1928, the total fuel bill was 132¼ tons of Iowa soft coal, of a rather low grade, which is low considering the load and continuity of service.

Effect of a Smouldering Fire

An interesting indication of the efficiency of the furnace was obtained through this change in the use of the building. The janitor fell into the habit of carrying a smouldering fire in the furnaces in order to maintain a little heat and avoid the trouble of re-kindling. It was found under these conditions that the temperature of the flue gas passing through the economizer fell below 212 degrees, the steam from the gases was condensed and a soup formed of the moisture and the ash in the bottom of the economizer. The trouble was corrected by the elimination of the smouldering fire, letting the fire go out when heat was not needed.

The Furnace Fan System in a Garage

An application of the furnace fan system to a garage is in the Regent Garage located in Kansas City. This is a single room 247 ft. x 108 ft. with an average height of 17 ft. It contains 452,000 cubic feet of space and has a wood roof covered with composition roofing but

Any successful extension of warm air heating to large buildings must have as its foundation just as sound and true engineering knowledge and experience as is required for the application of any heating system

with no insulation, supported on steel trusses. A light story or monitor runs about 4/5 the length of the building. Some store rooms are built in connection with the garage building but are entirely separated from it and are heated by a separate plant.

The normal heat loss of the garage is approximately 1,430,000 B.t.u. However, there are two very large doors facing the west for the entrance and exit of cars. These doors are automatically controlled, but a test showed that the approximate time between the opening and closing of the doors for the entrance or exit of a car was approximately one minute. The number of times the doors are opened of course varies greatly, but on an assumed extreme condition of a northwest wind, zero weather and one door or the other opening almost constantly, it was estimated there might easily be an additional heat loss through the doors of 500,000 B.t.u. Therefore a furnace was selected, equipped with an oil burner, both capable of producing approximately two and a half million B.t.u. per hour.

The main warm air riser is near the southwest corner of the building and the return air opening in the floor between the warm air riser and the corner, an unusual arrangement, making the distribution by volume circulation rather difficult. Care was taken to see that the volume of air recirculated was about 40,000 c.f.m. or about 1/11 of the cubical contents of the building, which was 452,000 cubic feet. This volume gives a very satisfactory distribution of the heat to the north end of the room despite the fact that the main entrances were in the middle of the west side of the building. The monitor undoubtedly helped to carry the warm air past these doors without interference. A thermometer test made when the outside temperature was —8 deg. fahr. showed that all along the north wall of the building it was approximately one degree warmer than it was in the south end near the warm air riser. This is not an unusual result in large volume recirculation. A smoke test in this building showed a general movement of the air in the upper level from the south toward the north and in the lower level from the north toward the south. The warm air travelled through the higher level until it struck the obstruction of the north wall where it turned down, showing the temperature slightly higher than the other parts of the room. The plant was so arranged that, by the opening of a damper, flushing in addition to that of the open doors could be produced by the fan. Since an efficiency test in this case involved a test of the oil burner as well as the heating plant itself, no attempt was made to make one.

Heating a Cotton Mill

The application of the system to a cotton mill located at Sand Springs, Oklahoma, is perhaps the largest, in two respects, application of warm air heating to date: one in the floor area heated from a single location; and the other in the B.t.u. loss of the building. This mill has a saw tooth roof, very low in proportion to the floor area, and apparently involving great difficulty in distributing the heat from a single inlet.

The building is 240 ft. wide, 780 ft. long and 12 ft. high to the bottom of the beam supporting the low point of saw teeth. There is a total of 187,000 sq. ft. of floor area or over 4 acres. There is 55,000 sq. ft. of glass and 225,000 sq. ft. of uninsulated wood roof.

The cubical contents amounts to 3,370,000 cu. ft. and the heat loss 12,168,000 B.t.u. (figured on a basis of 70 degrees inside at zero outside).

The heating plant is shown located in a lean-to building in the center of the north side, divided into two sections so that either department of the building may be heated separately or, as is most frequently the case, the partition is open and the building is heated as a single room.

Fig. 1 shows the arrangement of the fans and furnaces; the cross-section shows the air passing from the floor of the mill through the fans, over the furnaces, under a concrete deck, then passing back above the deck and discharging into the room directly above the return air opening. A deflector is shown extending beyond the concrete deck to prevent short-circuiting between the two openings. The warm air is carried far enough from the openings so that the suction of the fan has ceased to act upon it.

The two return air openings are each approximately 40 ft. long and 7 ft. high, a total of 560 sq. ft. for the entire building. The warm air openings above the deck are approximately the same area.

In each group are six furnaces having a rated capacity of 1,000,000 B.t.u. per furnace but with a safety factor in the rating making it possible to use them on this building which was to be continuously heated. Furnaces were equipped with gas burners supplied from a high pressure line belonging to the owner of the building.

The air was driven over these furnaces by four modified cone fans seven feet in diameter and each belted to a 7½ hp. motor. There is a complete air recirculation approximately once every ten minutes.

Test Made

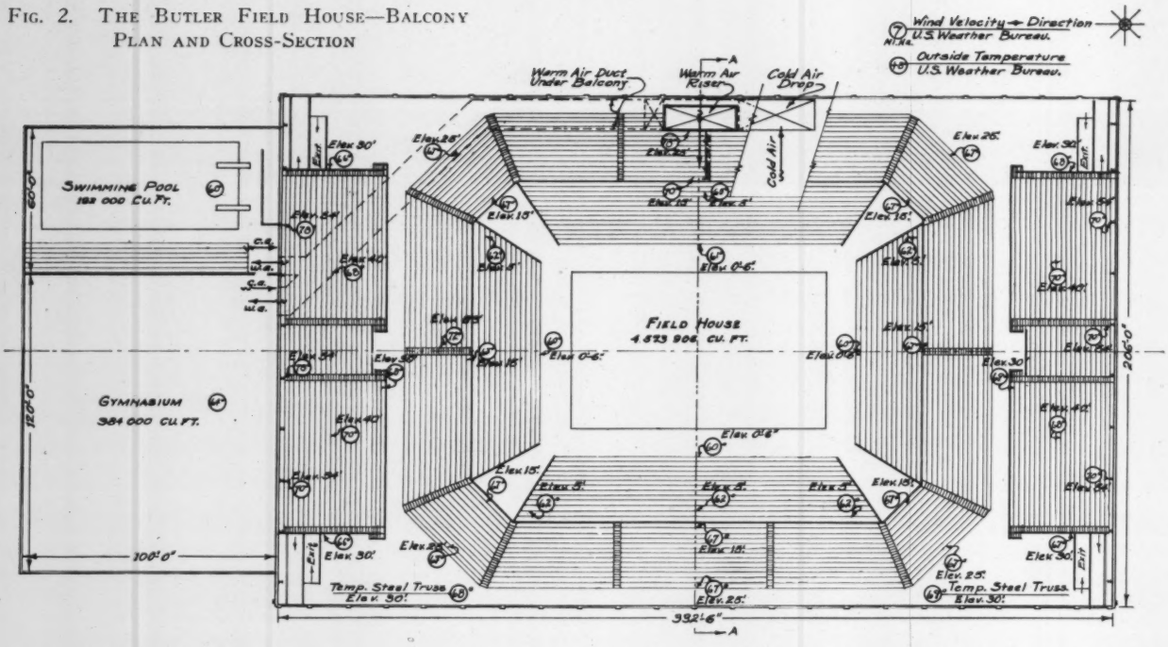
A test was made on this plant when it was five degrees below zero with no machinery in operation. Twelve thermometers were placed in different locations over the building at the five-foot level and there was a variation of only two degrees in temperature, the building being heated to 74 deg. for the highest reading and 72 deg. for the lowest.

There were no meters to measure the gas, hence no efficiency test was possible and no attempt was made to test anything except the capacity and the distribution.

Largest Space Heated by Warm Air

What we believe is the largest space heated by a warm air installation in the world is the Butler University Field House located at Indianapolis, Indiana (Figs. 2 and 3). It contains three main rooms. The swimming

FIG. 2. THE BUTLER FIELD HOUSE—BALCONY PLAN AND CROSS-SECTION

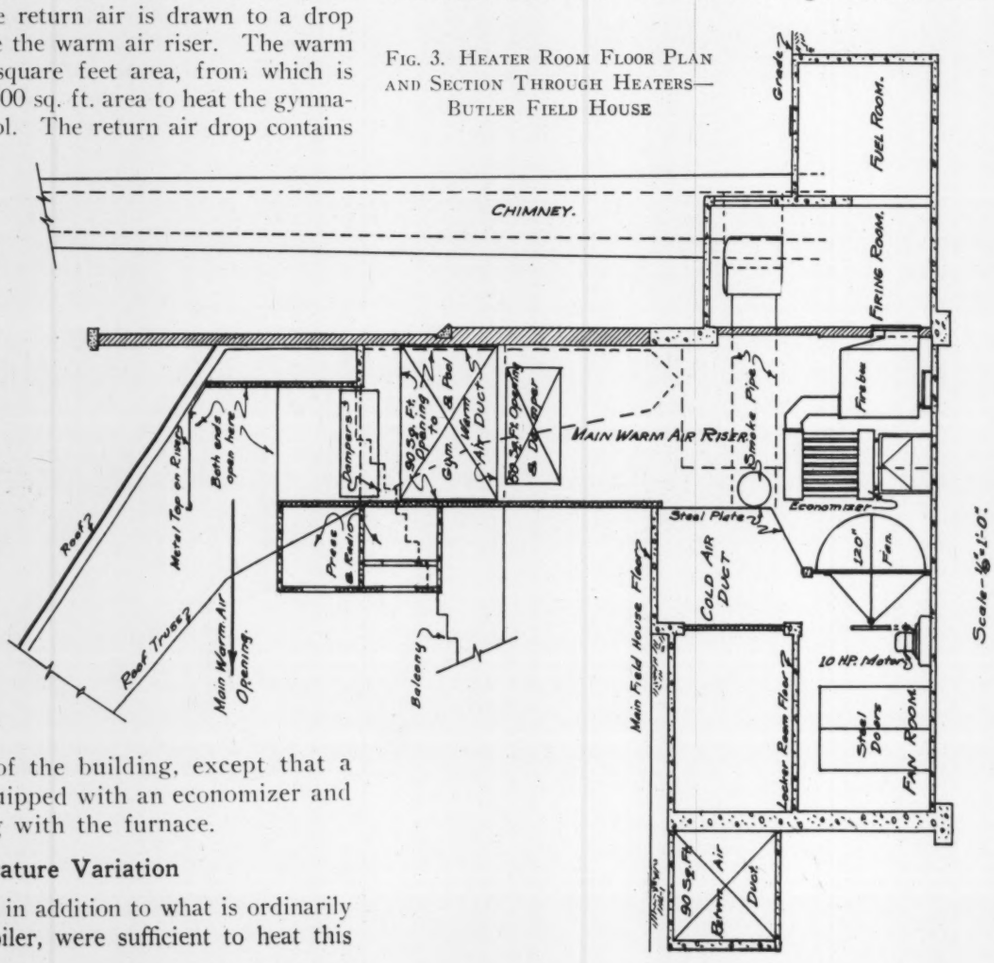


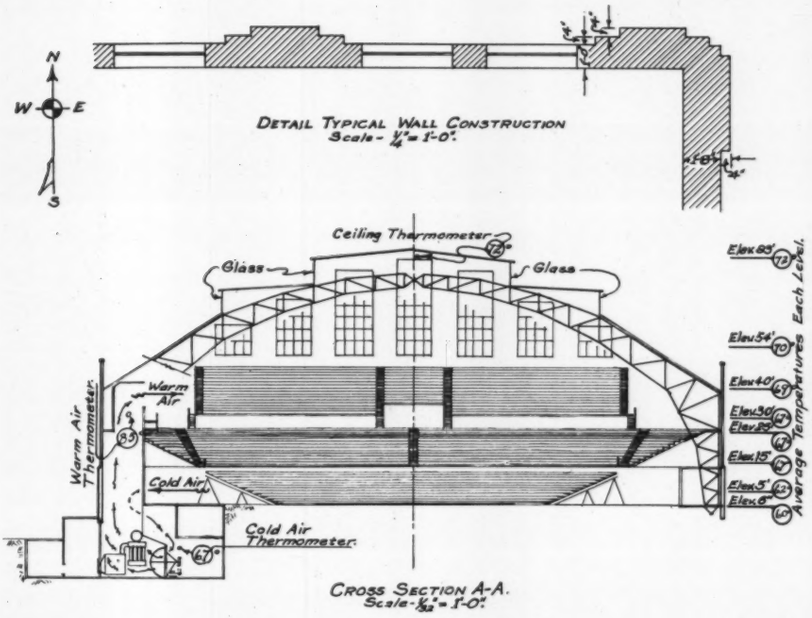
pool contains 192,000 cubic feet. The gymnasium contains 384,000 cubic feet and the Field House proper contains 4,574,000 cubic feet, making a total of 5,150,000 cu. ft. on the main floor. The main room seats 15,000 people at a basket ball game. It covers a floor area 333 ft. x 206 ft. and is 85 ft. high in the center, and is heated from a single warm air riser located in the center of the north side. The return air is drawn to a drop riser immediately beside the warm air riser. The warm air riser contains 500 square feet area, from which is taken a branch duct of 100 sq. ft. area to heat the gymnasium and swimming pool. The return air drop contains 400 square feet, the other 100 feet being drawn from the gymnasium and swimming pool through a separate duct. The vestibules, and some small remote rooms on a lower level not shown in the illustration, are heated with unit heaters using steam from a separate boiler which also heats the water for the shower baths and the swimming pool. But aside from the vestibules and remote small rooms, the steam has nothing whatever to do with the heating of the building, except that a steel boiler is used, equipped with an economizer and set in the same casing with the furnace.

Temperature Variation

Three large furnaces, in addition to what is ordinarily waste heat from the boiler, were sufficient to heat this building quickly and satisfactorily in the coldest weather of the past winter. (See Fig. 3.) A test of this plant was made February 1, 1929. It was started at 8 A. M., at which time the government thermometer registered —5 degrees, an unofficial thermometer on the north side of the building registering —12 degrees. The test was continued until 8 P. M. when the government ther-

FIG. 3. HEATER ROOM FLOOR PLAN AND SECTION THROUGH HEATERS—BUTLER FIELD HOUSE





EFFICIENCY AND TEMPERATURE DISTRIBUTION TEST OF HEATING PLANT, FEB. 1, 1929. TIME: 7:00 P.M. SKY: CLOUDY. DRY BULB: 63 DEG. WET BULB: 50 DEG. R.H.: 38%. HIGHEST TEMPERATURE: 72 DEG. LOWEST TEMPERATURE: 60 DEG. AVERAGE: 67 DEG.

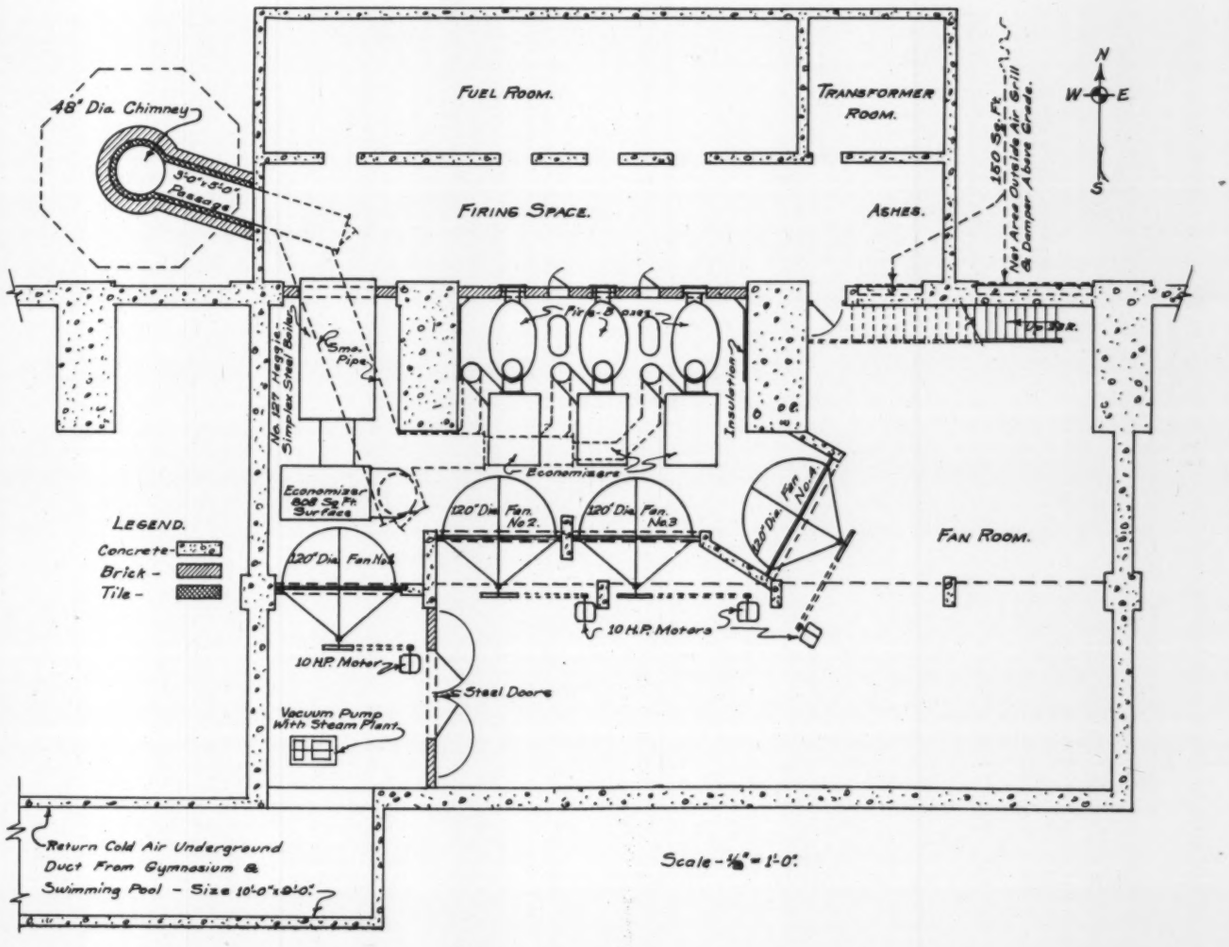
AT START OF TEST, OUTSIDE TEMPERATURE WAS —5 DEG. INSIDE TEMPERATURE, 33 DEG.

TEMP. VARIES 1 DEG. AT 6 IN. LEVEL
TEMP. VARIES 3 DEG. AT 5 FT. LEVEL
TEMP. VARIES 3 DEG. AT 15 FT. LEVEL
TEMP. VARIES 3 DEG. AT 25 FT. LEVEL
TEMP. VARIES 3 DEG. AT 30 FT. LEVEL
TEMP. VARIES 2 DEG. AT 40 FT. LEVEL
TEMP. VARIES 0 DEG. AT 54 FT. LEVEL
7 DEG. DIFFERENCE IN FIRST 15 FT. ELEVATION
0 DEG. DIFFERENCE IN NEXT 15 FT. ELEVATION
3 DEG. DIFFERENCE IN THIRD 15 FT. ELEVATION
12 DEG. DIFFERENCE IN 83 FT. ELEVATION
AVERAGE WAS 1 DEG. IN 7 FT.

mometer read plus 5 degrees and the thermometer on the north side of the building read zero. The average temperature for the day according to the weather bureau was zero.

The inside temperature at the beginning of the test was 33 degrees and at 7 P. M. readings were taken on 44 thermometers, the low ones at the 6-in. level reading 60 degrees. The high ones at the 83-ft. level read 72 degrees. At the 6-in. level there was a variation of one degree over the area, at the 5-ft. level a variation of three degrees, at the 15-ft. level a variation of three degrees, and at the 54-ft. level there was no variation.

The temperature at the 6-in. level was 60 degrees; at the 15-ft. level 67 degrees, or 7 degrees rise in the



Glass above 50' level - 8090# x 1.1 B.T.U. x 70° — 692,230 B.T.U.
Glass below 50' level - 6943# x 1.1 x 60° — 458,238 B.T.U.
8" Brick wall above 50' level - 6342# x 42 x 70° — 186,455 B.T.U.
12" Brick wall below 50' level - 14,166 x 32 x 60° — 271,987 B.T.U.
16" Brick wall below 50' level - 20,102# x 26 x 60° — 313,591 B.T.U.
20" Brick wall below 50' level - 3256# x 23 x 60° — 44,939 B.T.U.
Roof - 1" Fibrofelt - 5 Ply Asbestos - 77,992# x 27 B.T.U. x 70° — 1,474,048 B.T.U.
4" Cement floor - 28,258# x .38 B.T.U. x 15° — 131,391 B.T.U.
Moist earth floor - 33,400# x .35 x 15° — 175,560 B.T.U.
Wood floor with sleeper on earth - 6400# x 13 x 15° — 12,480 B.T.U.
Leakage - 4,573,906 cu ft x .9896* x .019 B.T.U. x 60° x ¼ change/hr. — 1,290,006 B.T.U.
Total heat loss for Field House Main Room — 5,050,919 B.T.U.
Glass in Gym. - 792# x 1.1 B.T.U. x 60° — 52,272 B.T.U.
12" Brick in Gym. - 5368# x .32 x 60° — 103,065 B.T.U.
Roof on Gym. - 12,000# x .27 x 65° — 210,600 B.T.U.
Floor in Gym. - 12,000# wood on earth x .13 B.T.U. x 15° — 23,400 B.T.U.
Leakage-Gym. - 384,000 cu ft. x .9896* x .019 B.T.U. x 60° x ¼ — 108,301 B.T.U.
Total Heat Loss for Gymnasium — 497,639 B.T.U.
Glass in Pool - 1056# x 1.1 B.T.U. x 60° — 69,696 B.T.U.
12" Brick wall in pool - 3474# x .32 B.T.U. x 60° — 66,701 B.T.U.
Roof on Pool - 6000# x .27 x 65° — 105,300 B.T.U.
Leakage - 192 000 cu ft. x .9896* x .019 B.T.U. x 60° x ¼ change — 54,150 B.T.U.
Total Heat Loss for Swimming Pool — 295,847 B.T.U.
Total Heat Loss for Building per Hour — 5,844,405 B.T.U.

HEAT ABSORBED BY MATERIALS IN BUILDING.

Steel Roof deck above 50' level - 300,000 lbs. x .11 B.T.U. x 40° — 1,320,000 B.T.U.
Steel Roof trusses above 50' level - 1,200,000 lbs. x .11 x 40° — 5,280,000 B.T.U.
Steel roof trusses below 50' level - 464,000 lbs. x .11 x 30° — 1,531,200 B.T.U.
Steel balcony trusses - 972,000 lbs. x .11 x 30° — 3,207,600 B.T.U.
Gaurd rails & misc. steel - 60,000 lbs. x .11 x 30° — 198,000 B.T.U.
Concrete in balconies & ramps - 4,484,660 lbs. x .21 B.T.U. x 30° — 28,253,000 B.T.U.
Inside tile partitions - 620,000 lbs. x .195 B.T.U. x 30° — 3,627,000 B.T.U.
Air in building - 5,149,906 cu ft. x .9896* x .019 B.T.U. x 30° — 2,904,880 B.T.U.
Ice melted & evaporated (.000917 lbs. x 38% r.h. - .000441 lbs. x 48% r.h.) x 5,149,906 x .9896* x (1448 B.T.U. + 33 B.T.U. + 971.7) — 809,144 B.T.U.
Total heat absorbed by materials in building — 47,130,824 B.T.U.

HEAT REQUIRED FOR 12 HOURS - 0° OUTSIDE - 35° TO 63° INSIDE.

Heat loss first hour - 5,844,405 ÷ 2 — 2,922,202 B.T.U.
Heat loss second hour - 5,844,405 x .7 — 4,091,085 B.T.U.
Heat loss third hour - 5,844,405 x .9 — 5,259,965 B.T.U.
Heat loss third to twelvth hours - 5,844,405 x 9 — 52,599,645 B.T.U.
Heat to raise temperature of materials inside 30° — 47,130,824 B.T.U.
Total heat required for 12 hours — 112,003,721 B.T.U.
Average heat required per hour — 9,333,560 B.T.U.

*.9896 is correction factor for barometric pressure during test 2/1/29.

Outside Temperature U.S.W. Bureau.	Condition of sky.	Movement of Wind U.S. W. Bureau.	Average Inside Temperature.	Temperature of Steel Roof Trusses.	Central Standard Time.
−4° F.	Cloudy.	8 mi/hr N.	33°F.	34° F.	8:00 A.M.
− 1°.	Cloudy.	9 mi/hr. N.	43°	38°	9:00 A.M.
+ 2°.	P. Cloudy.	6 mi/hr. N.	49°	44°	10:00 A.M.
+ 4°.	Clear	9 mi/hr. NW.	55°	52°	11:00 A.M.
+ 5°.	Clear	10 mi/hr. NW.	60°	55°	12:00 M.
+ 8°.	Cloudy	9 mi/hr. NW.	63°	62°	1:00 P.M.
+ 9°.	Cloudy	8 mi/hr. NW.	68°	66°	2:00 P.M.
+ 11°.	Cloudy	8 mi/hr. NW.	70°	68°	4:00 P.M.
+ 8°.	Cloudy	7 mi/hr. NW.	67°	68°	8:00 P.M.

Note - Fires were lighted 7:30 A.M. - Fans were started 8:00 A.M. - Furnaces were fired at capacity 8:00 A.M. to 4:00 P.M. then checked. - Building had not been heated for 7 days.

SUMMARY OF TEMPERATURE DISTRIBUTION 8:00 P.M.

Highest temperature (at ceiling) — 72°.
Lowest temperature (at floor) — 60°.
Average temperature of 41 thermometers — 67°.
Temperature variation over room at level 6 inches above floor — 1°.
Temperature variation over room at level 5 feet above floor — 3°.
Temperature variation over room at level 15 feet above floor — 3°.
Temperature variation over room at level 25 feet above floor — 3°.
Temperature variation over room at level 40 feet above floor — 2°.
Temperature variation over room at level 54 feet above floor — 0°.
Temperature difference 6 in. above floor & 5 ft. above floor - 2°.
Temperature difference 6 in. above floor & 15 ft. above floor — 7°.
Temperature difference 6 in. above floor & 25 ft above floor — 7°.
Temperature difference 6 in. above floor & 30 ft above floor — 7°.
Temperature difference 6 in above floor & 40 ft. above floor — 9°.
Temperature difference 6 in above floor & 54 ft. above floor — 10°.
Temperature difference 6 in above floor & 83 ft. above floor 12°.
Average temperature difference per 7 feet elevation — 1°.

CALCULATION SHEET NO. 1. HEAT LOSS PER HOUR

first 15 ft. The temperature at the 30-ft. level was 67 degrees; at the 45-ft. level, 70 degrees, and at the 83-ft. level, 72 degrees. The average rise in temperature was ½ degree per foot in the first 15 ft. and 1/7 degree per foot in the total vertical range of 82 ft. The low temperature at the high level means much less heat lost through the roof. These figures represent the average of the various thermometers, the average making up in part for the inaccuracy which characterizes most thermometers.

The fans on anemometer test moved 358,000 c.f.m., giving a recirculation change for the entire building once every 14 minutes. All three of the rooms were handled from a single warm air inlet in each room and a single return air outlet located in each case almost immediately below the warm air inlets.

The small difference in temperature between the floor and the ceiling illustrates one of the causes of fuel economy in a system of this sort.

The special apparatus used has been developed to such size that three large furnaces furnished the heat for this immense building. It should be said, however, that the building is well constructed and covered with an insulated metal roof, the insulation being of sufficient thickness so that the heat loss is small in proportion to the space.

CALCULATION SHEET NO. 2. CHART OF TIME REQUIRED TO HEAT THE BUTLER FIELD HOUSE—FEB. 1ST., 1929

Two tests were made, and both times the temperature outside was zero or below. Calculation sheet No. 2 gives the record of test, made February 1, 1929, by hours and a summary of the temperature distribution at the conclusion of the test.

The volume of air entering the fans was very carefully measured by an anemometer and was found to be 341,770 c.f.m. The method of measuring and calculation is shown in calculation sheet No. 3. The duration of the test was 720 minutes. The average temperature rise of the air was 26 degrees and this multiplied by .01777 gives 113,691,294 B.t.u. as the amount of heat put into the air during the test. The boiler and its economizer furnished 1,306,368 B.t.u. of this amount, leaving 112,384,926 B.t.u. furnished by the three furnaces.

The coal burned in the furnaces was exactly 9,000 lb., with a correction for moisture of 180 lb., making a net 8,820 lb. of dry coal. This coal is rated to produce 14,250 B.t.u.

CALCULATION SHEET No. 3. VOLUME OF AIR DELIVERED BY FANS

per lb., making a total of 125,685,000 B.t.u. available in the coal burned. Therefore the heat shown in the temperature rise of the air moved and heated by the furnaces is 89.4 per cent of the available heat in the coal. The complete figures are shown in calculation sheet No. 4.

Results Checked by a Second Method

This result has been checked by an entirely different method of calculation. The temperatures at the different levels were taken into consideration. The tested coefficients of conductivity for the various materials were used and the heat losses of the building were calculated to be 64,872,897 B.t.u. for the duration of the test. The weight of the steel and the concrete in the interior construction was computed. Using the specific heats of the materials, it was found that 47,130,824 B.t.u. were required to raise the temperature of this interior material from 33 to 65 degrees. The complete figures are shown in calculation sheet No. 1.

These two figures added together give a total of 112,003,721 B.t.u. estimated heat required to give the results shown in the twelve hour test. This is 381,205 B.t.u. less than the heat output of the furnaces as estimated by measuring the volume and temperature rise of the air. It is also estimated that the by-product heat from the boiler and its economizer amounted to 1,306,368 B.t.u. for the duration of the test. One added to the other shows a discrepancy between the two calculations of 1,687,573 B.t.u. or about 1.4 per cent. See calculation sheet No. 4.

Conclusions

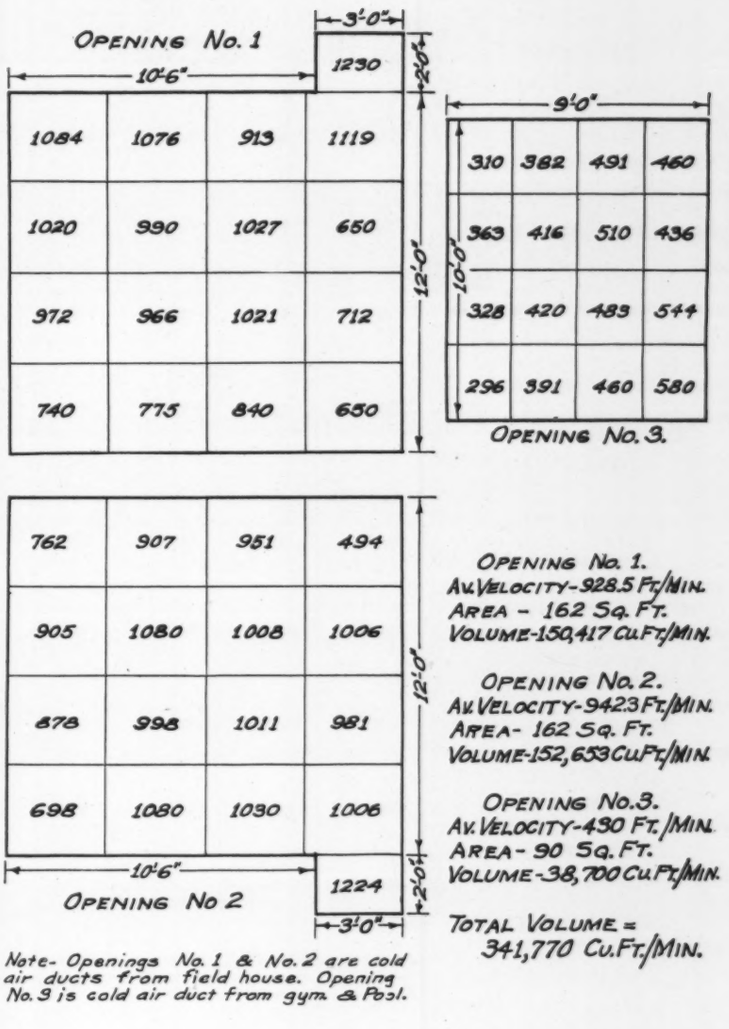
From these tests and examples the following conclusions are drawn:

1. The furnace fan system, properly designed and applied to large rooms, is highly efficient.

2. Large volume recirculation distributes the heat horizontally on any given level in the largest rooms tested, with such a small variation as to be negligible.

3. Large volume recirculation lowers the discharge temperature and reduces the difference in temperature between the low and the high levels to such an extent that the heat loss of the building is reduced and a decided saving in fuel results.

4. Although 15,000 people gather in this room for approximately three hours for basket ball contests it has never been found necessary to use the outside air inlet for ventilation. The rapid circulator uses all of the tremendous volume of air in the building which keeps odors, etc., diluted below the noticeable point.



OPENING No. 1.
AV. VELOCITY-928.5 FT./MIN.
AREA - 162 SQ. FT.
VOLUME-150,417 CU.FT./MIN.

OPENING No. 2.
AV. VELOCITY-942.3 FT./MIN.
AREA- 162 SQ. FT.
VOLUME-152,653 CU.FT./MIN.

OPENING No. 3.
AV. VELOCITY-430 FT./MIN.
AREA- 90 SQ. FT.
VOLUME-38,700 CU.FT./MIN.

TOTAL VOLUME = 341,770 CU.FT./MIN.

Note- Openings No. 1 & No. 2 are cold air ducts from field house. Opening No. 3 is cold air duct from gym. & Pool.

CALCULATION SHEET No. 4

OVERALL EFFICIENCY OF HEATERS.

Input = 9,000 lbs. "Loredo" W.Va. coal. Htg. value per pound dry 14,500 B.T.U.
Net Input = (9000-180 lbs. water) x 14,250 B.T.U. ——— 125,685,000 B.T.U.
Output = 341,770 cu. ft. air x 720 min. x .01777 B.T.U. x 26° — 113,691,294 B.T.U.
.01777 is B.T.U. to raise 1 cu. ft. dry air at 29.61" pressure
1°F at average temperature of 75°F. or
Wt. at 75° x Cp x 29.61 ÷ 29.921.
Heat furnished by boiler & economizer = 108,864 B.T.U. x 12 hrs 1,306,368 B.T.U.
Net output of furnaces ——— 112,384,926 B.T.U.
Overall Efficiency of furnaces = Input ÷ Output = 89.4 %.

ANALYSIS OF DATA.

Total heat supplied to building for 60° rise for 12 Hours 113,691,294 B.T.U.
Estimated heat requirement for same period ——— 112,003,721 B.T.U.
Heat loss unaccounted for ——— 1,687,573 B.T.U.
Error in estimating heat loss in ratio to heat actually supplied 1.4%.
Heat supplied by each furnace per hour ——— 3,121,803 B.T.U.
Coal burned per furnace per hour — 245 lbs.
Coal burned per Sq. Ft. grate area per hour — 12.5 lbs.

Pressure Reducing Valves

By Sabin Crocker

IN PURCHASING a pressure reducing valve, or more correctly speaking a pressure regulator, the question frequently comes up, "Why can not one be selected from a catalog the same as a globe or gate valve?" It is the primary purpose of this article to explain how operating conditions vary in so many respects that a selection of the regulator best suited to the service is not always so simple. In explaining this point it will be well to start with the fundamentals of how pressure reducing valves operate.

Principles of Operation

The action of a reducing valve in regulating the service pressure is to adjust automatically the rate of flow through the valve port to suit varying requirements of the equipment or heating system which it supplies. In other words, the valve opening must adjust itself to maintain a constant pressure in the service line irrespective of how much or how little steam is used at any particular moment. In making this explanation, it is convenient to deal with some particular fluid such as steam, although the principles involved apply equally well to gas or air or even to liquids. Many different devices are employed to actuate the disc and make it respond to pressure changes in the service line. Nearly all of these devices utilize a loaded diaphragm of some sort as the sensitive element which detects changes in service pressure and acts either directly or indirectly to move the disc.

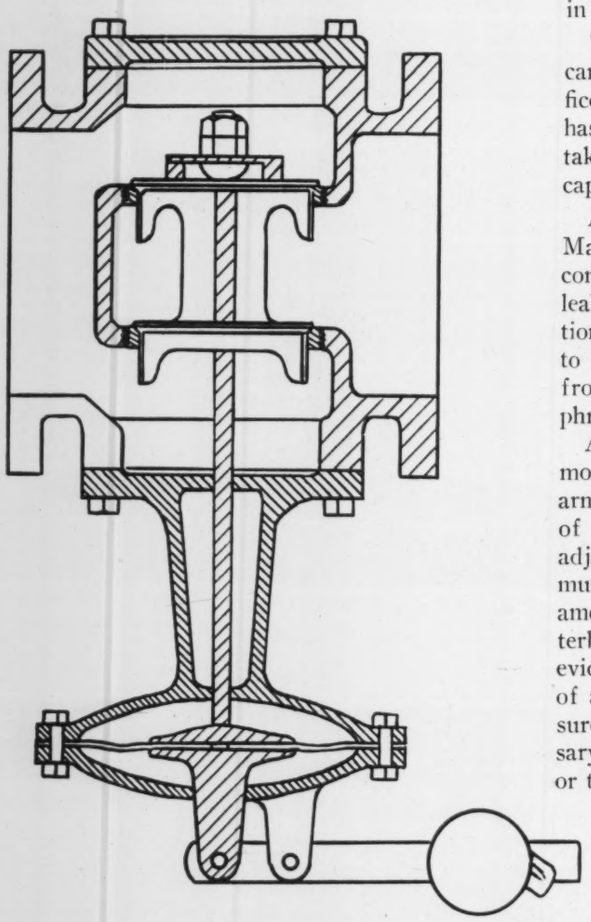


FIG. 1. DIRECT ACTING PRESSURE REGULATOR

Direct Acting Pressure Regulator

A simple type of pressure regulator having a direct acting diaphragm loaded with a weight is shown in Fig. 1. This regulator is of the two-seated piston type in which the thrust is balanced in both directions, thus permitting free response to any small impulse from the diaphragm. The service pressure side of the valve is connected through an internal passage with the upper side of the diaphragm. The under side of the diaphragm is vented to atmosphere and loaded with a weight whose position is adjustable along a lever arm. Due to the equalized thrust on the valve piston, the weight and lever arm are free to raise the piston until the service pressure builds up to a point sufficient to load the diaphragm enough to counterbalance the thrust of the weight and lever arm. A further increase in service pressure would tend to close the valve, thus maintaining that pressure constant. The action of the valve is to find a position of the piston which gives a port opening just sufficient to pass the weight of steam required in the service line.

The amount of port opening required for any flow can be computed by the formulas for flow through orifices as explained in a later paragraph. When the piston has reached its full lift, no further increase in flow can take place, and the valve is then passing its maximum capacity of fluid.

Absence of a stuffing box may be observed in Fig. 1. Many engineers believe there are advantages in such construction because of the probability of sticking or leaking caused by the stuffing box. The inverted position of the valve allows the space above the diaphragm to fill with water which tends to protect the diaphragm from damage through contact with steam. Rubber diaphragms are used generally in this type of valve.

Adjustment of the service pressure is obtained through moving the weight to the right or left along the lever arm. Inspection of Fig. 1 indicates that while the action of the valve is independent of the inlet pressure, the adjustable range of service pressure, within the maximum flow capacity of the valve, is limited by (a) the diameter of the diaphragm; (b) the weight of the counterbalance; and (c) the length of the lever arm. It is evident that any particular valve of this type is capable of adjustment over some definite range of service pressure, and that if a different range is desired it is necessary to change the diameter of diaphragm, the size weight, or the length of lever arm. Such valves for low service

pressures are fitted with larger diaphragms than for higher service pressures.

Pilot Operated Pressure Regulator

A single-seated pressure regulator of the pilot operated, spring loaded diaphragm type is shown in Fig. 2. The operation of this valve is explained as follows, referring to the lettered parts of the figure. Steam entering at *A* passes through the main valve port *H* to outlet *B*. The initial pressure acting through internal passage *C* enters chamber *P* through pilot valve *K* and thence to piston chamber *J*. The delivery pressure, passing through internal pilot passage *E*, raises the diaphragm *D* against the adjusting-spring thrust and allows the pilot valve spring to close the pilot valve *K*. Pressure in chamber *J* is then equalized by leakage around the piston and through ports *G* into the discharge chamber leading to the service line, thus allowing the main valve spring to close the main valve. Any reduction of service pressure below normal allows the adjusting spring to force down the diaphragm, thus opening the pilot valve and allowing the initial pressure to enter the chamber again and force down the piston which opens the main valve. Service pressure is adjusted by changing the tension of the adjusting spring. The adjustment once made, the service pressure will remain essentially constant regardless of any variable volume of discharge, or variation of the initial pressure, so long as the latter is in excess of the delivery pressure, and the discharge capacity of the valve is not exceeded.

Analysis of the design shown in Fig. 2 indicates that the service pressure range over which this regulator can be adjusted depends upon the diameter of the diaphragm and the stiffness of the adjusting spring. Any single combination of these parts yields satisfactory regulation over approximately a 10-lb. service pressure range. For instance, a certain adjusting spring used with a given diameter diaphragm would be suitable for adjustment to hold any pressure desired between 5 and 15 lb. If a pressure between 15 and 25 lb. were desired, a slightly heavier spring would be required with the same diaphragm. A larger diaphragm is required for low service pressures than for high in order to obtain enough thrust and reaction between the diaphragm and adjusting spring to insure positive action of the moving parts.

A pilot-operated regulator with a large diaphragm suitable for pressures as low as 5 lb. gage is shown in Fig. 3. Several features in this valve which distinguish it from the valve shown in Fig. 2 are worth mentioning. Discharge pressure is led to the diaphragm through an external pilot line which can be connected into the service piping at any convenient point considered as having pressure conditions representative of those desired in the service line. The disc of this valve has a flat seat with a projecting spool which, it is claimed, serves to protect the seat from cutting action at reduced flow.

Selection of Proper Size Regulator

In selecting the proper size regulator for any job, it is necessary, of course, to have the valve large enough to handle the maximum demand corresponding to its peak load conditions. It also is desirable that the valve be of a size which will require an appreciable lift of the disc at minimum and average loads on the system, if cutting action from wire-drawing is to be avoided. The latter requirement sometimes dictates the use of two reducing valves in parallel as shown in Fig. 4, one to be used for light loads and the other, or both, for heavy loads. The regulators may, or may not, be of the same size as service conditions may indicate. In any event it is desirable to avoid operating a regulator at loads much below 1/3 its rated capacity. In the case of steam supply to a heating system to which are connected water heaters or other equipment operated in summer as well as in winter, it is advisable to have a small regulator of a size suitable for the summer load, and one or more larger regulators in parallel which are capable of carrying the entire winter load. In cold weather the summer service regulator then can be cut out to advantage. An alternate arrangement, which saves keeping the main header warm in summer, is to serve the all-year load with a small header, whose heat loss will be comparatively low, through a small reducing valve supplying this header alone. Another advantage of the small reducing valve with separate header is the ability to carry a somewhat higher pressure on the water heater than is desirable on the heating system proper, thus affecting some economy in the first cost of water heater and piping.

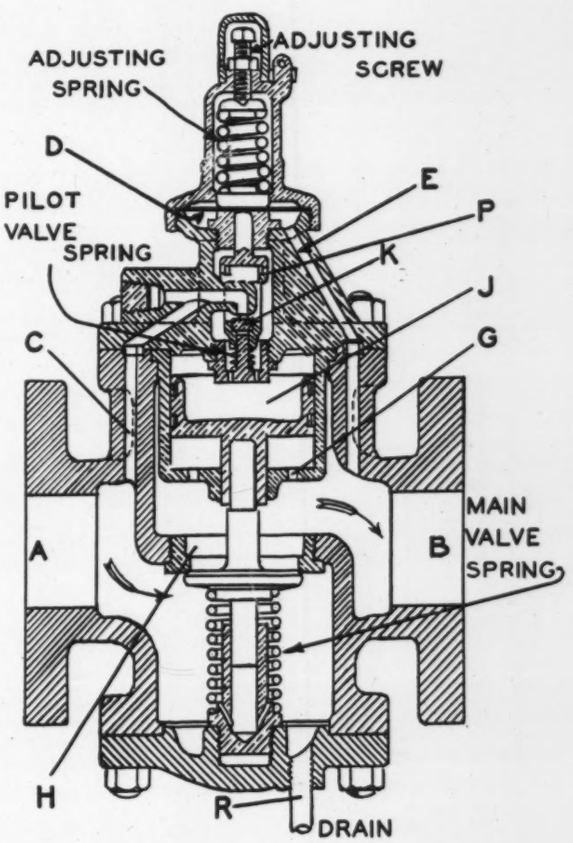


Fig. 2. Pilot Operated Pressure Regulator With Small Diaphragm and Internal Pilot Passage

Fig. 4 also serves to illustrate certain important details of reducing station design. It is well to place a strainer ahead of reducing valves to catch pipe scale and other hard substances which might damage the valve seats. The line should be dripped on the high pressure side of the station to remove moisture which tends to collect there

when the valves are closed or nearly so. Pressure gages on the high pressure and service pressure sides are required for intelligent operation of the system. In case the service piping and connected equipment are not built to a standard capable of carrying full line pressure, an adequate safety valve (or valves) should be placed on the reduced pressure side. The standard of construction used on the high pressure side should be continued through to the last stop valve ahead of the safety valve, as this section of the line may be subjected to full pressure when the stop valve is closed. In important installations, stop valves should be placed on both sides of each reducing valve so that it can be removed for repairs without discontinuing service. A hand operated by-pass (not shown in Fig. 4) is desirable, but its maximum capacity should not exceed that of the reducing valve (or valves).

Capacity of Pressure Regulators

The maximum capacity of a pressure regulator depends upon the initial pressure, the free area through the port, and the lift of the disc. In the case of air, steam or gas, the rate of flow can be computed by Napier's rule or similar formulas for flow through orifices. With dry saturated steam where the absolute pressure in the service line does not exceed 0.6 the initial absolute pressure, Napier's formula probably is the most convenient to apply.

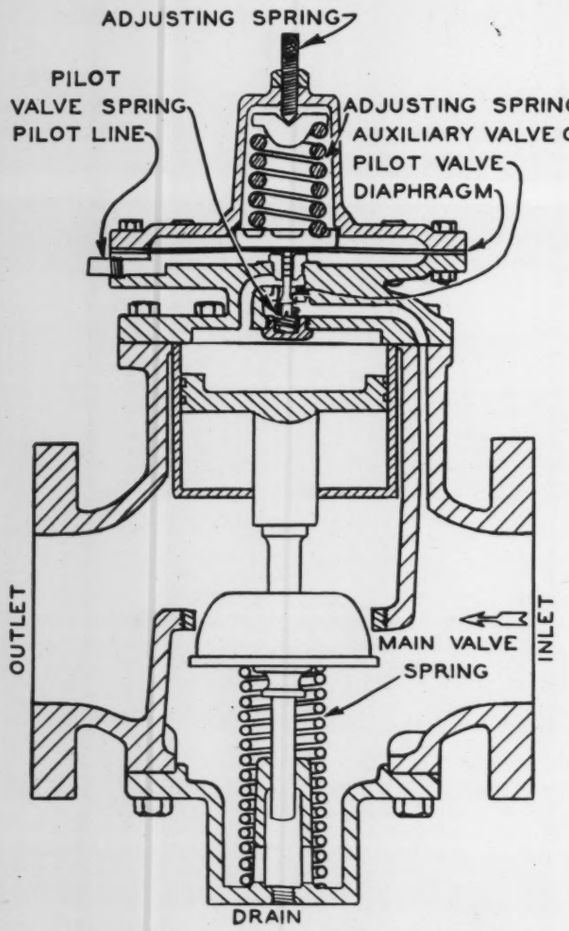


Fig. 3. Pilot Operated Pressure Regulator for Low Pressure Regulation With Large Diaphragm and External Pilot Line

This formula is: $W = 50\ PA$, where W is saturated steam flow in lb. per hour; P, the initial absolute pressure in lb. per sq. in.; A, the area of the orifice in square inches, which in this case is the free area through the port; and 50, a constant for steam.

This formula is incorporated in paragraph A-11 of the *A. S. M. E. Boiler Construction Code* where it is applied to safety valves. From the similarity of flow conditions between safety valves and pressure regulators, it is apparent that if this formula applies to one it should to the other. Par. A-11 referred to treats different shaped seats as follows:

Safety Valves

"*A*-11 *Method of Computing Discharge Capacity.* The required discharge capacity of a safety valve or valves for a boiler may be based either on the heat units in the fuel consumed or on the amount of steam generated.

"The number of heat units in the fuel that each safety valve will handle per hour, for valves of the ordinary types in which the discharge capacity is proportioned to the lift, may be obtained as follows:

$U = 161{,}000 \times P \times D \times L$ for bevel seats at 45 deg.

$U = 227{,}500 \times P \times D \times L$ for flat seats

$U = 72{,}500 \times P \times A$ for seats of any angle

"The amount of steam that a valve will discharge in pounds per hour, may be found as follows:

$W = 110 \times P \times D \times L$ for bevel seats at 45 deg.

$W = 155 \times P \times D \times L$ for flat seats

$W = 50 \times P \times A$ for seats of any angle

where

U = Number of heat units in the fuel that a safety valve will handle per hour, B.t.u.

W = Quantity of steam that a safety valve will handle per hour, lb.

P = Absolute boiler pressure = gage pressure + 14.7 lb. per sq. in.

D = Inside diameter of valve seat, in.

L = Vertical lift of valve disc, measured with 3 per cent excess pressure, in.

A = Relieving area in sq. in. = $3.1416 \times D \times L \times$ sine of seat angle."

In the case of a balanced regulator with double ports, it is evident that the total quantity discharged will be the sum of the quantities passing through the two ports as determined separately by the above formulas. The lift will be the same for both ports, although their diameters may be different. Similar formulas are available in handbooks and engineering texts for air, gas and liquids, and for cases where the service pressure exceeds the critical back pressure for flow through an orifice.

Care Required in Selecting a Regulator

Returning again to the point mentioned in the opening paragraph regarding care required in selecting the proper regulator for a particular job, the author has attempted to point out the wide range of service conditions and inter-related features of construction which make an offhand selection impracticable. Unless complete information regarding any design of regulator is available, it is

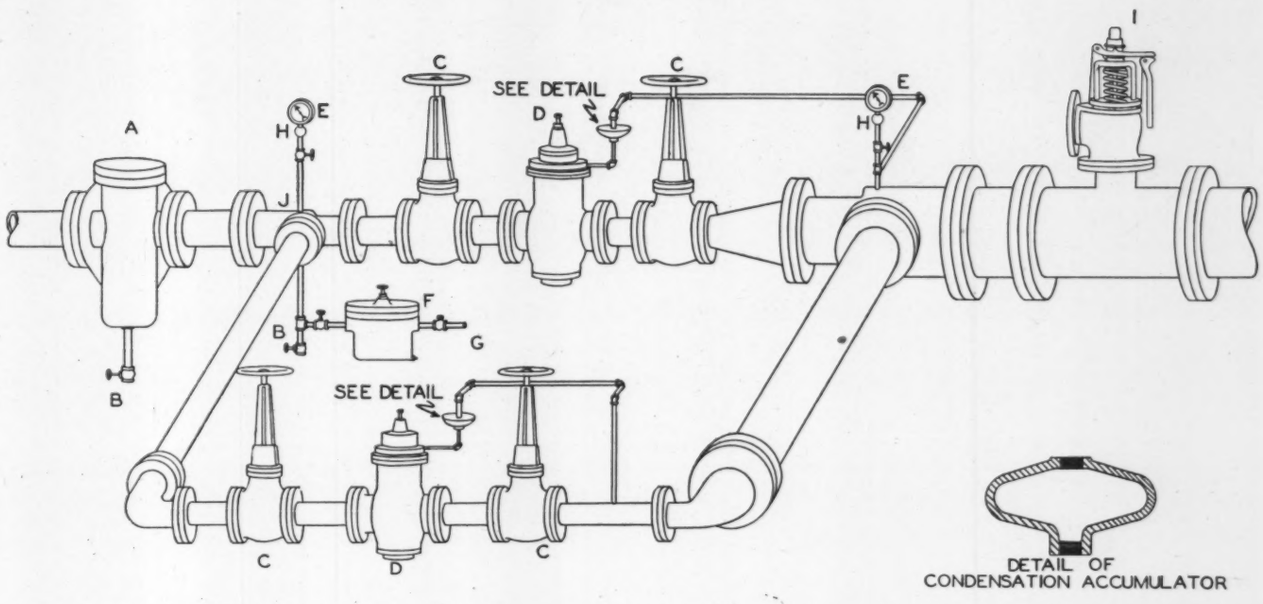


FIG. 4. PRESSURE REDUCING STATION WITH TWO REGULATORS IN PARALLEL. A—FLANGED STRAINER. B—OPEN BLOW. C—GATE VALVE. D—PRESSURE REGULATOR. E—PRESSURE GAGE. F—BUCKET TRAP. G—CHECK VALVE. H—WATER SEAL. I—SAFETY VALVE. J—FLANGED TEE WITH SIDE OUTLET FOR DRIP.

impossible even to make an intelligent guess as to what it will do under any assumed conditions of service. The service pressure maintained depends upon the diameter of diaphragm, resistance factor of springs employed and other details of design not ordinarily available to the engineer specifying a regulator. The maximum capacity of the regulator depends upon the diameter and number of ports, upon the lift of the disc, and upon the initial pressure or the relation of initial pressure to service pressure. Considering the involved nature of the problem, the average engineer intending to buy a regulator would not care to take the responsibility of selecting it without seeking advice from the designer and manufacturer of the valve.

Simplification and Standardization

These terms are much in our minds and on our lips these days when all are working for the elimination of waste. They are not synonymous though the processes by which they are accomplished are somewhat similar. Sometimes simplification precedes standardization as a separate process. Most often, however, simplification and standardization are accomplished at the same time.

For example, when the Sectional Committee took up the standardization of cast iron and steel flanges and fittings, under the procedure of the *American Standards Association,* it first eliminated more than fifty-one per cent of the sizes that had been listed as standard. It did more. The committee listed as special and then omitted entirely pipe sizes 4½, 7, 9, 11, 15 and 22 inches.

Designers and engineers of all types of apparatus involving the use of pipe fittings are urged to co-operate in this phase of the elimination of waste process in industry.—*A. S. M. E.*

Activities of *A. S. T. M.* Committee on Wrought Iron

Physical tests and chemical analyses have been completed on a series of staybolt irons made by two manufacturers. In manufacturing the specimen bars, the phosphorus only was varied, all other elements, i.e. (carbon, manganese sulphur and silicon) being as nearly as possible normal. The results will be presented in the committee's report for 1930.

Tentative revisions of minor importance were adopted in the following Standard Specifications:

A 72-27 for Welded Wrought-Iron Pipe.
A 84-27 for Staybolt and Engine-Bolt Iron and Refined Wrought-Iron Bars.
A 86-27 for Hollow Rolled Staybolt Iron.

The committee expressed interest in the work of the Sectional Committee on Standardization of Wrought Iron and Wrought Steel Pipe and Tubing, in the work of preparing specifications for the following special classes of pipe:

Hammer Welded Pipe
Resistance and Fusion Welded Pipe
Riveted Pipe
Lock Bar Pipe
Other types that may come up later.

The Sub-Committee on Nomenclature and Definitions has been instructed to prepare a definition for wrought iron without including in the definition any reference to the process by which the iron is to be made. When a satisfactory definition is adopted, the various specifications of the Society, for wrought iron products, will be revised by the elimination of process clauses and the incorporation of quality standards which can be measured by definite tests.—G. H. Woodroffe, Secretary.

Air Conditioning and Refrigerating Large Bakeries

Article No. 2

By Walter L. Fleisher

Two Kinds of Dough to Be Considered

I HAVE not mentioned, so far, the fact that doughs are of two kinds: one is straight dough, and the other is sponge dough. Either or both of these may be used in the same bakery. In a sponge dough, which a great many people think gives better quality bread, only part of the flour is mixed with the ingredients and water at one time, and additional flour and water added for an additional mix after fermentation in the sponge dough has taken place.

This is mentioned at this time due to the fact that there is a slight additional heat of chemical affinity which must be taken care of in a sponge dough room. However, having determined the number of heat units dissipated into the room and knowing the condition of the air leaving the conditioner, it is easy to figure the quantity of air at 69 deg. required to overcome the heat inflow to maintain 80 deg. in the room. However, it must be borne in mind that even though the air leaves the conditioner at 69, there is a rise in temperature due to the resistance of the fan and ducts and heaters which amounts to at least 1 deg., and that therefore the available temperature rise for a 69 dew point and an 80 dry bulb condition of the room is probably in all 10 deg. and may be only 9½. With inefficient design of duct work this may even come down to 9 deg.

As has been said, this calculation determines the quantity of air required in the room. However, practice indicates that this quantity must certainly be more than the amount that may leak out through the doors and windows. This is one of the refinements of air conditioning engineering that only practice in the particular industry would determine. However, having determined the quantity of air and the amount of this which must be removed and the amount recirculated, the problem of figuring the refrigeration is a simple matter.

This is the second of two articles by Walter M. Fleisher on air conditioning and refrigerating for large bakeries. The first article appeared last month and dealt with the ingredients and processes used in bread baking; normal regain of ingredients and of the finished loaf; humidity requirements of ingredients and of the finished bread; storage of bread baking supplies; temperature of cold storage rooms; why refrigeration is essential to proper air conditioning of a large bakery; maintenance of proper mixing temperatures; three cooling expedients which may be resorted to; calculations for refrigeration requirements; ventilation of the dough room; necessity for maintenance of exact conditions in the dough room; heat balance problem in dough room air conditioning; placing the mixers; and heat transmission figures for an ideal dough room.

The present article takes into consideration such questions and points as the character of doughs; calculations of refrigeration requirements; maintenance of constant conditions; circulation of air; fundamental principles of air conditioning for bakeries; corrosion in proof boxes; cooling of finished bread, etc.

The author's remark that the problems involved in dough room conditioning are the underlying problems of every air conditioning calculation makes this an article worthy of study by engineers in every industry.

Figuring the Refrigeration

The refrigeration required is obviously the difference of total heat of the air entering the conditioner and leaving the air conditioner. In other words, if the recirculated air enters the conditioner at 73 deg. wet bulb, it contains 36 heat units per lb. of air and if it is brought down to 69 deg. dew point, or saturation point, it has 32½ heat units per lb. of recirculated air, so 3½ heat units per lb. would have to be removed by refrigeration.

Assume that 20 per cent of the air is from out of doors at a 78 deg. wet bulb; that has 41 B.t.u. per lb. which must be brought down to 32½, or 8½ heat units per lb. removed. From our calculations it is seen that 2,500 c.f.m. are required, or with the motors in the room the total quantity of air required to be circulated is 4,000 c.f.m. Approximately, this 4,000 c.f.m. is 300 lb. Sixty lb. of this has 8½ heat units per lb. removed, or a total of 510 B.t.u.; 240 lb. has 3½ heat units, or approximately 840 B.t.u., making 1,350 heat units removed in the total quantity of air handled in order to maintain the required condition. This is approximately seven tons of refrigeration and this seven tons of refrigeration can be supplied in a number of ways:

First, by introducing the right quantity of water at a low temperature.

Secondly, by installing direct expansion coils in the conditioner.

Thirdly, by means of a baudelot coil in a chamber under the conditioner and made practically an integral part of it.

Each of these methods has frequently been used. It is interesting to note in this calculation that the 20 per cent of outside air at 78 deg. wet bulb takes over two-thirds as much refrigeration as the 80 per cent of recirculated air at 73 deg. wet bulb. One can therefore readily see how rapidly the refrigeration requirements vary with the outside wet bulb.

This is not only true of the problem which I have presented, but is true of all air conditioning problems both for industrial purposes and for comfort.

Particular stress is laid upon the air conditioning of the dough room of the bakery, not because the dough room of the bakery is of any more importance than several other departments in the bakery but simply because the problems involved in dough room conditioning are the underlying problems of every air conditioning calculation.

A Heat Problem Which May Modify the Cooling Problem

In the preceding paragraphs the method of calculating the air quantities and refrigerating quantities has been explained but there is a heat problem in the dough room which may modify the cooling problem. The one condition that remains constant in the conditioner at all seasons of the year is the dew point. It may, therefore, be necessary at many times of the year to apply not only refrigeration but heat at the same time. Eighty-degree dry bulb is as essential to fermentation as the 69 deg. dew point, and if the heat transmission is not due to a 95 deg. outside dry bulb on which condition the system was calculated, then sensible heat must be put into the air by means of a radiator or a re-heater to raise the dry bulb of the entering air above the dew point temperature.

Assume, for a minute, that the out door conditions are 87 deg. dry bulb, then the transmission would not be such as to raise the quantity of 69 deg. air that is brought into the room to 80 deg., and sensible heat would have to be added to this air before it answered its purposes. This same conditioner, however, must be adequate and must be equipped to take care of the most severe winter conditions. The air entering from outside may have to be brought from a condition of zero deg. wet bulb to 69 deg. wet bulb, which means the introduction of heat into the water instead of the extraction of heat from it, and the air leaving the conditioner may have to be brought from 69 to 120 deg. in order to maintain an 80 deg. dry bulb.

Fig. 1—Make-up Department on 2nd Floor. Note the Overhead Dry Proofer or Rest Proofer. This Is Not Conditioned But According to the Author's Theory Should Be at 70 Per Cent Relative Humidity

Require Constant Conditions Automatically Controlled

The change from cooling of water to heating of water, the heating of air and the non-heating of air, the change in the setting of the recirculation and fresh air dampers must be simple and act automatically, because as has been stated, 80 deg. dry bulb and 70 per cent relative humidity is a constant condition for a dough room and not a maximum or a minimum, and therefore the automatic controls must be ready to function at any time or at any season. Some of the best-informed specialists in the bakery field contend that improper or unconstant conditions in the dough room are responsible for holes in the loaf, which today are considered one of the principal signs of poor bread.

How Constant Conditions Are Maintained

At this point I want to explain how these constant conditions required are taken care of automatically. Quite a number of them are covered by patents. To maintain the 69 deg. dew point in the conditioner a 3-way valve may be installed on one side of which is the refrigerated water connection, and on the other side a steam connection. This 3-way valve has a thermostatic bellows or diaphragm valve which is actuated by a change in temperature in the water. As the temperature of the water rises the element expands and allows the refrigerated side of the 3-way valve to open, introducing additional cold water. As the temperature becomes correct the expansion element contracts and closes off the valve. As the temperature of the water drops still further, another port is opened due to the contraction of the expansion element and steam is admitted through the 3-way valve to the water. Another thermostat is located in the room itself and, with rising or falling temperature in the room, the thermostat, having been set for 80 deg. dry bulb, steam is admitted to or shut off from the re-heater which is located on the leaving end of the conditioner. The recirculating and fresh air dampers are connected together and a differential thermostat actuates one valve when the variation between the inside wet bulb and the outside wet bulb tends to separate or come together so that

more or less outdoor air is admitted depending on whether the outside wet bulb is above or below the inside wet bulb. The majority of air conditioning installations are controlled by some modification of these methods.

Circulation of Air in Dough Room

It was previously stated in this article that circulation of air in a dough room was of great importance. In the first place it is essential to get the conditioned air over the tops of the troughs but without creating a draught. It is therefore essential that the distribution should be thorough but that no more duct work should be incorporated than is absolutely essential for proper distribution. How to accomplish this seeming paradox is one of the arts of air conditioning. Narrow streams of air close to the ceiling at such velocity as to mix thoroughly with the air in the room, but which have lost their velocities when they reach the top of the troughs, is an excellent method of distribution. As it is essential to recirculate most of this air, it is necessary to collect it and bring it back to the conditioner. This requires additional duct work which must be designed with the same conditions in mind as for the entering air. When the dough room and mixer room are separated, the design of the duct work is simplified, but when the mixers with their motors are located in the dough room it is essential to have the air moved towards the mixers and collected beyond them in order to prevent the heat and other variables of the mixing process from interfering with the conditions in the room.

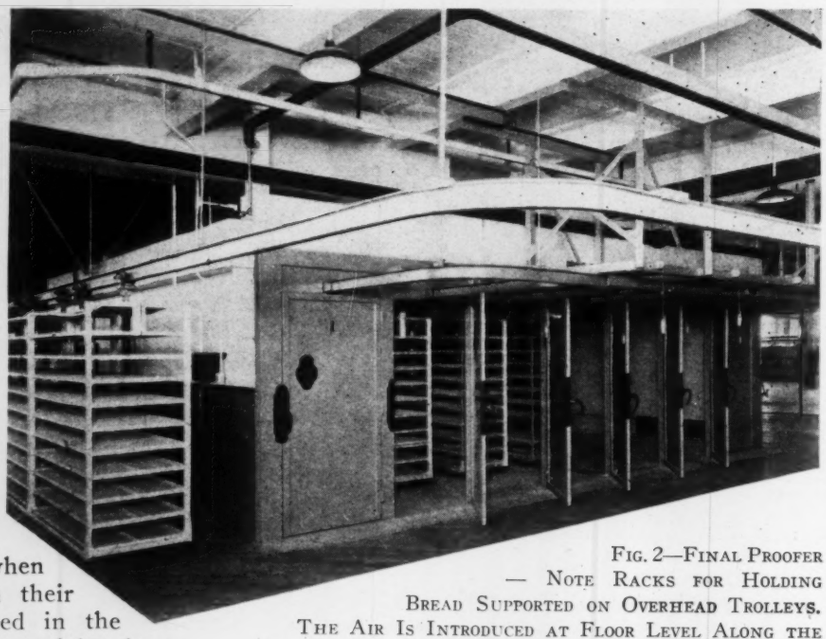


Fig. 2—Final Proofer — Note Racks for Holding Bread Supported on Overhead Trolleys. The Air Is Introduced at Floor Level Along the Sides of the Box. The Apparatus for Conditioning Is Overhead on the Box.

Knowledge of Thermodynamics and Fundamentals of the Industry Required

As was stated before, I have gone into rather complete detail of the air conditioning of the dough room. This is done to show the problems that arise in all air conditioning work. One can see from this description that to design and calculate air conditioning requires a knowledge of thermodynamics with its heat balances both from the standpoint of steam and refrigeration, air movement, sheet-metal design, fan systems, pumping systems, and control, not to mention a thorough knowledge of the fundamentals of the industry for which the system is being designed. With this description and detail of calculations let us now proceed to the other parts of a bakery without going into such minute details as to the methods of arriving at results.

Make-up Department

After the doughs have been fermented, which is a process taking from three and one-half to five hours, they are removed from the dough room and put into the make-up department. This is an important department in the bakery, but it is doubtful whether adverse conditions in this particular department have as great an influence on the finished loaf as do conditions in other departments. In this department, where the dough is divided into the proper-sized chunks and weighed and rounded, the yeast is so disturbed that it must go through a rest period before proceeding farther in the process of bread making. In a modern, large bakery all of the work in a make-up department is practically automatic and very little handling is done manually.

The rest period mentioned takes place in a semi-enclosed conveyor which consists principally of a travelling belt. In this conveyor the dough again assumes a crust to hold the pressure of the yeast fermentation, and then the dough is put into pans preparatory to what is known as final proofing. It is the contention of many bakery engineers that this department should also be conditioned and at a dry bulb temperature of about 85 deg. and 70 per cent relative humidity.

Some Special Problems in Air Conditioning a Bakery

It may be interesting here, to survey the intricate problems that arise in air conditioning. Practically all of the belts which convey the recuperating doughs are made of linen, and linen has a different hygroscopic normal regain than the dough itself. Therefore with proper air conditioning in the make-up department, the belt itself would very likely become moist, and the doughs lying on the belts would become soggy or run. Therefore, if proper conditions are maintained in the make-up department the belt carrying the doughs must be specially treated because of the different regains.

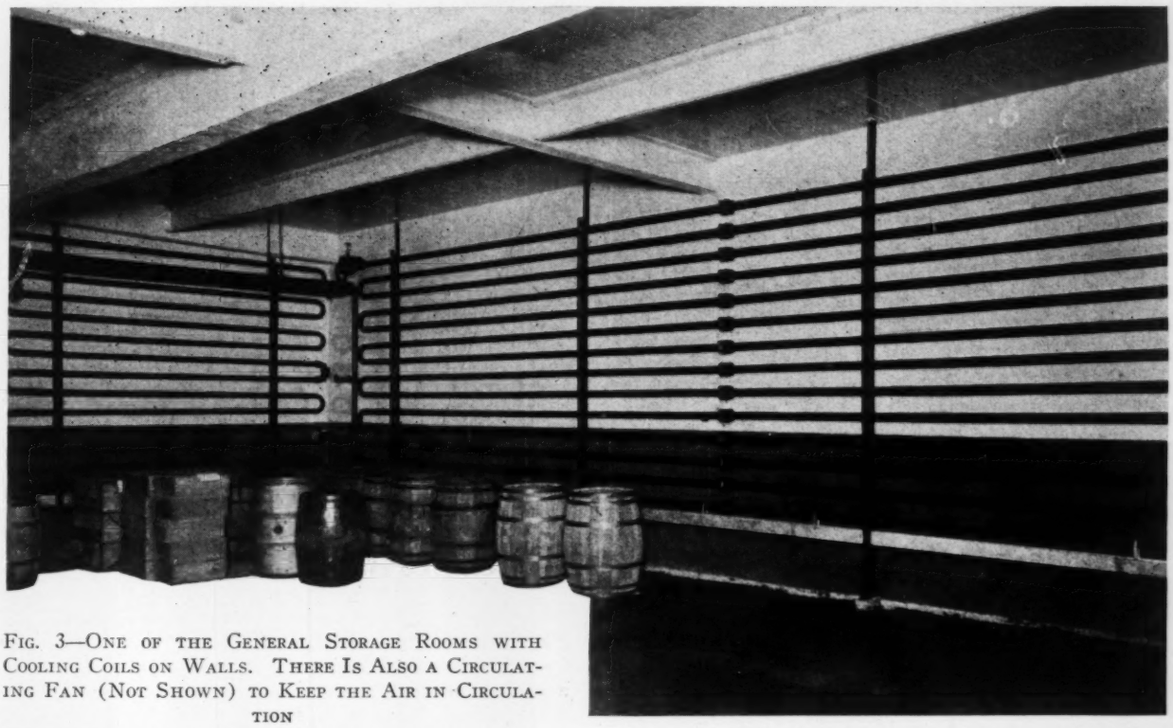


FIG. 3—ONE OF THE GENERAL STORAGE ROOMS WITH COOLING COILS ON WALLS. THERE IS ALSO A CIRCULATING FAN (NOT SHOWN) TO KEEP THE AIR IN CIRCULATION

Importance of Uniform Conditions in Proof Box

After the doughs have gone through a rest period of ten to fifteen minutes they are put into pans of the size desired for the loaf and put in a final proofer, which is usually a box or cabinet in which a number of racks of bread or doughs are placed. This proofer is then subjected to a fairly high temperature and a high wet bulb, because under the conditions maintained in this box, the yeast performs its final work and expands the rounded lump of dough into a symmetrical shape. Many bakers and engineers claim that the proper and uniform conditions of the final proofer are nearly the most essential conditions for the production of a good loaf. The conditioning of a proof box is more nearly universally an air conditioning problem than any other part of the bakery. In fact the final proofer is an outgrowth of the earliest recorded air conditioning problem in the world. The air conditioning of the proof box takes the place of the dampening or wetting of the dough before baking.

The average recognized condition for the proofer is 95 deg. and 70 per cent relative humidity. Depending upon the length of time that it is desired to keep the dough in the proof box, and dependent also upon the amount of yeast mixed with the doughs, will be the length of time that the doughs are left in the proof box. This time may vary from thirty minutes to two hours and it varies not only according to the size of loaf desired, but also to the amount of yeast mixed with the ingredients.

Uncertain Conditions in Use of Older Methods

The air conditioning of a proof box is rather simple —in fact it is essential that it should be, because for many years direct heating coils in the box and introduction of live steam answered every purpose of the baker. However, the use of this method required constant attention on the part of an attendant during the proofing period and the heating effect of the sensible heat in the steam, and the cooling effect due to recurrent condensation and evaporation, upset conditions so regularly that the baker was never sure that all his loaves were uniformly proofed in size or that he was getting the proper contact between the moisture-laden heated air and his various pans. Except in isolated instances, the air conditioning of the proof boxes is a straight humidifying proposition. In certain isolated instances it is true that the proof box has a tendency to rise above the 94 or 95 deg. dry bulb desired, and in such cases the air must be introduced into the box at a temperature low enough to maintain the required temperature.

Ordinarily, due to the frequent opening of doors for the introduction of the racks, a temperature considerably higher than that desired to be maintained must be introduced. In the proof box, however, it is just as essential to eliminate draughts as it is in the dough room, and as the proof box is almost completely filled from floor to ceiling, this is a problem requiring considerable ingenuity.

The average baker is very critical of results in his proof box and, although the average proof box holds from four to twelve racks, each rack holding from 250 to 400 loaves, five or six improperly proofed loaves in one proofing will prejudice the baker against the operation of the box. Consequently it is very general to install recording dry and wet bulb instruments on a proof box so that the management may check the conditions in the box against the resulting bread. The control of the conditions in the proof box are not dissimilar to those for the dough room except that refrigeration is never required, but at most times steam must be introduced in some form

into the spray water to raise its temperature above the entering wet bulb temperature. The direct injection of steam thermostatically controlled from the wet bulb temperature of the returned air into the water to be sprayed, is the usual method of taking care of this contingency.

Corrosion Considered in Proof Box Installations

In the final proofer, the high temperature and the high absolute humidity combined with the carbonic

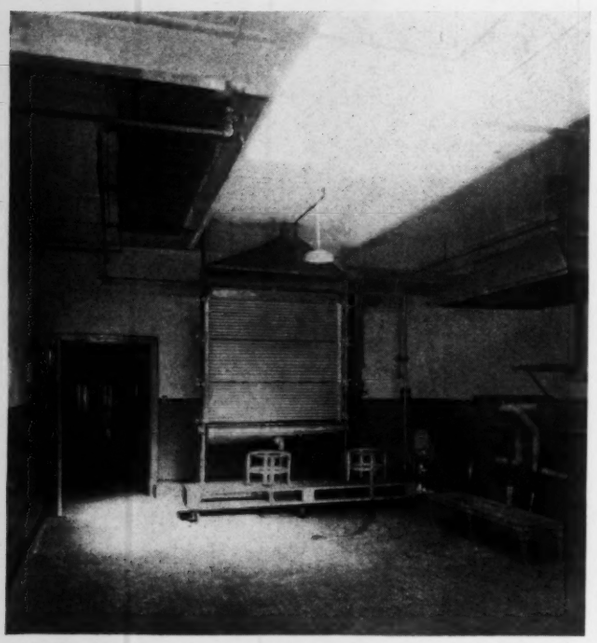


FIG. 4—MILK ROOM WITH STERILIZER AND COOLER. ALL THE MILK OF THE DAY IS RAPIDLY COOLED SO THAT THE REFRIGERATION REQUIRED IS USED AT A TIME WHEN THE AIR CONDITIONING SYSTEM IS CALLING FOR VERY LITTLE

acid gas given off by the dough has a very corrosive effect and consequently one of the problems of proof box conditioning in the bakery is to install nothing that would be affected by the acid condition of the box. It is therefore customary to make all the distributing duct work in a proof box of materials not affected by the dilute acid fumes.

The calculations for proof box conditioning have been determined in various ways. The heat losses from transmission through walls, ceiling, and floors, leakage around doors, and the necessary heat to raise the doughs from the entering condition of 80 deg. to the stabilized condition of 94 or 95 deg. are the elements entering into this calculation.

These transmission and other losses require usually a one-minute to a three-minute air-change in the proof box. A one-minute air change usually gives too large a volume of air to handle without crusting the loaves and a three-minute air change usually does not introduce enough air to give uniform proofing or it introduces the element of too great a differential between the entering and maintained temperature.

Care in Handling Risen Doughs

When the doughs have risen to completely fill the pans or slightly above the top of the pans, they are in a very unstable state. The gases, due to fermentation have practically completed their work and rough handling or shocks are likely to cause the doughs to fall. Cooling of the doughs would have the same effect. Therefore, very carefully and immediately after removing from the proof box, the pans containing the risen doughs are put in an oven where temperatures of 450 deg. with the addition of directly injected steam, kill the yeast spores and caramelize the crust. The bread is then baked for about one-half to three-quarters of an hour with gradually decreasing temperatures and the baked loaves leave the ovens at a temperature usually of about 200 to 250 deg. having lost, in the progress through the oven, about 10 per cent of their weight.

One of the big and expensive problems of the modern large bakery confronts the baker from this time until the loaf leaves the plant. This is the question of cooling his loaf and, incidentally, of wrapping it without the expenditure of too much time or expense or the propagation of mould in his finished loaf.

In the large bakery the oven in which the bread is baked is usually a travelling oven. The bread is conveyed through the oven in pans and as it leaves the oven the bread is dumped from the pans almost invariably by hand and at a temperature of about 250 deg. The progress of bread from its ingredients to the finished loaf in all large bakeries is on a definite time schedule, and this schedule is of about eight to nine hours duration. As the equipment is designed to maintain this schedule and as the routing of the bread to its destination is based on this schedule, it is essential that no elements enter into production which will retard or offset production.

Cooling of Bread Following the Baking

As the loaf is usually wrapped in wax paper before distribution, it would seem that the first step after the bread has left the oven would be to immediately wrap and ship it. However, this is not possible because the loaf at 200 deg. can not be wrapped without damage. This is due to several causes.

In the first place, the loaf at this temperature has a very high vapor pressure inside which is attempting to set up an equilibrium, and in doing so a certain amount of moisture is given off—in other words, in cooling, a loaf loses weight and this is due to the fact that a small amount of moisture, probably 2 to 4 per cent by weight, must be dissipated to establish equilibrium. Until this equilibrium has been established, the loaf should not be wrapped. Secondly if a loaf were wrapped at a high temperature, it is much more susceptible to mould and rope than if it were wrapped at a lower temperature. It has, therefore, by long experience, been determined that the proper temperature at which a loaf may be wrapped is around 95 deg. and this 95 deg. is not at the surface of the loaf but in the interior.

As the crust of a loaf is, in a way, case-hardened, it takes considerable time for both the moisture and the heat to percolate through. The modern baker has resorted to many methods of cooling the loaves as rapidly as possible before he wraps them, and the usual method in the large bakery is to deposit

the loaves on travelling belts or fingers or on conveyors of some kind which keep the loaves in motion until the temperature has dropped sufficiently for wrapping. In the winter time this cooling period approximates one hour and a quarter to an hour and a half, but in the summer, with high temperatures and high humidities, the loaves may remain above a desired temperature for as long as two hours and a half. This not only upsets the schedule of a bakery but very often results in poor quality loaves and the presence of considerable mould and rope.

A Problem of Great Interest to Air Conditioning Engineers

This is a problem of great interest for the air conditioning engineer. On its face, it would seem simple. Actually it is one of the most difficult problems in the bakery. I may admit that it has not been satisfactorily settled yet, except in one or two special cases. This is probably due to the fact that only a few plants have been equipped with air conditioning in connection with loaf cooling. However, there is an extremely interesting point in connection with this cooling which in my investigations I have discovered and have referred to incidentally in the early part of this article; that is, that when the loaf is finally cooled and in equilibrium, its moisture content corresponds to a relative humidity, or normal moisture content which is indicated by a relative humidity of 60 per cent. It would therefore seem probable, and my own investigations and installations have indicated that this is true, that the final air that is brought into contact with the loaf for cooling purposes must have approximately 60 per cent relative humidity no matter what its temperature, in order to maintain the proper condition in the loaf.

The difficulty in applying air conditioning to loaf cooling up to the present time has been primarily due to the fact that the manufacturers of loaf-cooling conveyors have designed their conveyors for special conditions rather than for air conditions. As the travel of these conveyors is very long, the manufacturer has usually attempted to keep the conveyor as close to the ceiling as possible and with as few passes as possible, so that the space under the conveyors might be utilized for other purposes, such as wrapping and sorting. The introduction of conditioned air to such an apparatus is almost impossible with any economy of installation. Besides, in those plants that are large enough to afford a loaf conveyor cooler, the quantity of air required to remove the sensible heat from the number of loaves cooled in a definite period is very great, the average cooler in a large bakery requiring from 15,000 to 20,000 c.f.m. of air per cooler. However, with a properly designed air conditioning system and the air entering around 65 deg. the cooling time can be cut down from one and a half hours to three-quarters of an hour, with a consequent saving in the size of the cooler and its accompanying equipment.

Interesting Experiments in Bread Cooling

Some very interesting experiments have been made on bread cooling at very low temperatures. By very low I mean ice-box temperatures of 30 to 50 deg. The laboratories which have conducted these experiments have promised interesting conclusions but I do not believe that many bread manufacturers will be found who would pay for the necessary refrigeration to obtain these results on a large scale, even though these results were better than any of us expect. My own calculations show that if temperatures as low as that were the desirable temperatures for bread cooling, the average large plant would require refrigeration of at least 100 tons capacity simply to take care of the bread cooling. Cooling due to natural evaporation, that is, bringing the air down to the temperature of the wet bulb will answer every purpose at most seasons of the year.

Simplication of the Baker's Steam Problem

It was stated in the beginning of this article that there were many interesting conditions in the bakery which would appeal to readers of this magazine outside of the straight air conditioning problems. One of these is the steam problem, for the baker is dependent upon steam for a number of his processes, such as the sterilization of milk and the fixing of the crust on the loaf in the oven. Up to a couple of years ago practically no bakery was operating without high pressure steam. Today the necessity for high pressure steam in a bakery has been eliminated and, to a large extent, with a reduction in costs.

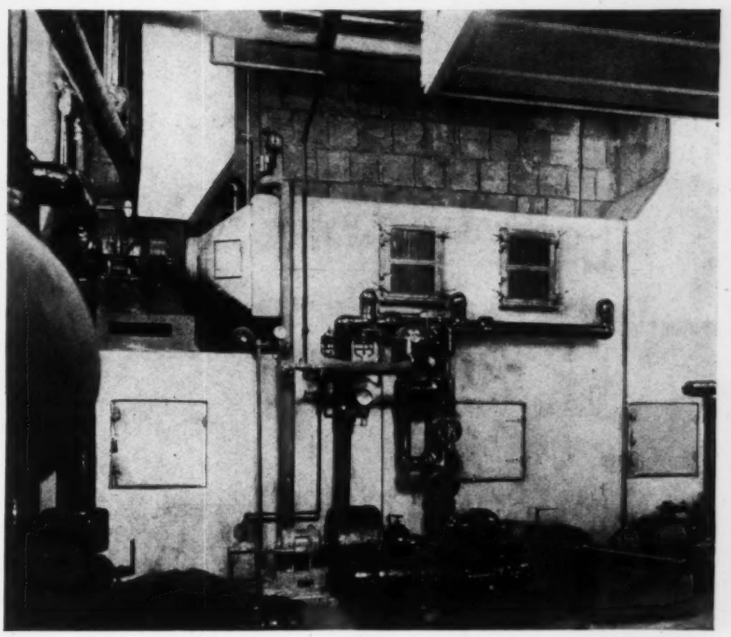


FIG. 5—APPARATUS AND REFRIGERATING MACHINE ROOM, SHOWING CONDITIONER WITH BAUDELOT UNDERNEATH AND PUMPS FOR CIRCULATING WATER AND BRINE. THE CONDENSERS CAN JUST BE SEEN BUT THE COMPRESSORS (AMMONIA) ARE NOT VISIBLE

In illustrating this article, photographs have been used of one of the most modern bakery plants in the country, the St. Louis-Missouri plant of the Ward Baking Company, to which company we desire to express our appreciation for their assistance.

Notes on Heating and Piping in Germany

By Arthur K. Ohmes

Several items that will be of interest to heating engineers are published herewith. They come from the notebook of a prominent American engineer who spent several weeks in Germany last summer.

THE writer spent some time in Germany during the past summer and looked over the heating and piping situation and from notes taken the following lines may be of interest to the readers of this publication.

The heating industry of Germany is guided very much by the "Verbandes der Centralheizungs-Industrie," which may be freely translated into "Union of the Heating Industry." This Union represents the interests of the contractors, manufacturers and engineers as far as central heating systems are concerned. This Union is highly organized and has its own bureau in Berlin in which both commercial and scientific matters are discussed, policies are determined, abuses abolished, etc.

The Union has lately given to its members, for their guidance and use, certain rules for the determination of heat losses of buildings and the required boiler and heating surfaces for heating systems. The rules are quite complete for they represent, as its President, Dr. Ing. Schiele, and its Director Dieterich informed me, a work of ten years, and all the important practical and scientific men in this field helped to make it as complete as possible.

The following data are given:

1. Basic discussions of heat formulae.
2. Factors involved in determining heat transmission.
3. Lowest outside temperature throughout Germany and Austria.
4. Data to be given by owner and architect of building to be heated.

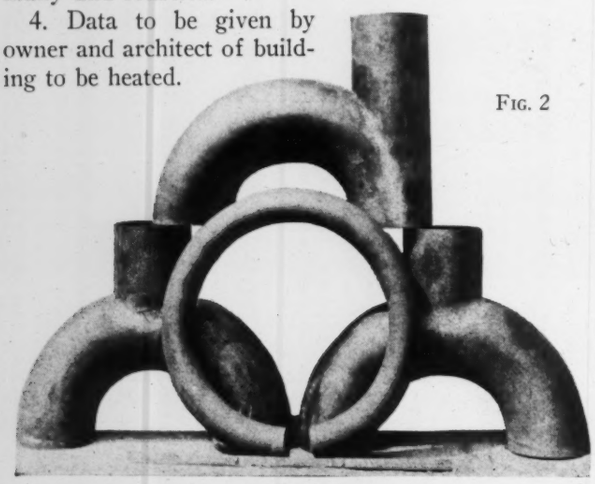


FIG. 2

5. Complete description of location and points of compass of building.
6. Inside temperature desired by owner and architect.
7. Discussion of inward leakage and allowance to be made.
8. Time of use of rooms and assumed time of operation of heating system.

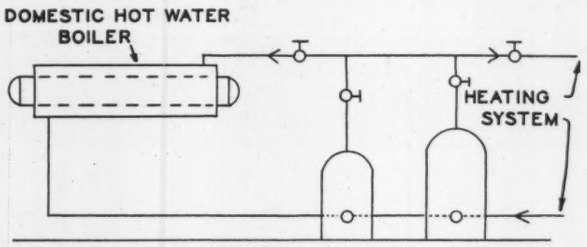


FIG. 1—WARM WATER SUPPLY HOOK-UP FOR DOMESTIC USE

9. Discussion of determination of heat transmission coefficients.
10. Discussion of heat transmission coefficients.
11. Choice of inside temperature, except if owners or architects mandate the inside temperature.
12. Additions to heat transmission figures for exposure, prevailing wind direction, whether inside or outside rooms, etc.
13. Example of figuring heat transmission.
14. Usual heat transmission coefficients to be used.
15. Heat losses through air spaces.
16. Heat transmission coefficients through walls—about 1400 coefficients given.
17. Heat transmission coefficients of roof—about 55 coefficients given.
18. Heat transmission coefficients through ceilings and floors—about 100 coefficients given.
19. Heat transmission coefficients through doors and windows—about 33 coefficients given.
20. Determination of boiler sizes.
21. Determination of heating surface. (1020 efficiencies given for various heating surfaces.)

Insofar as Germany is concerned, it seems as if the data given might well replace all similar data given in the numerous text books now in existence.

The same Union is now checking pipe sizes for steam and hot water heating systems and will prepare a booklet for the guidance of the heating industry as far as this part of the work is concerned.

In a small hotel, the hot water heating system was

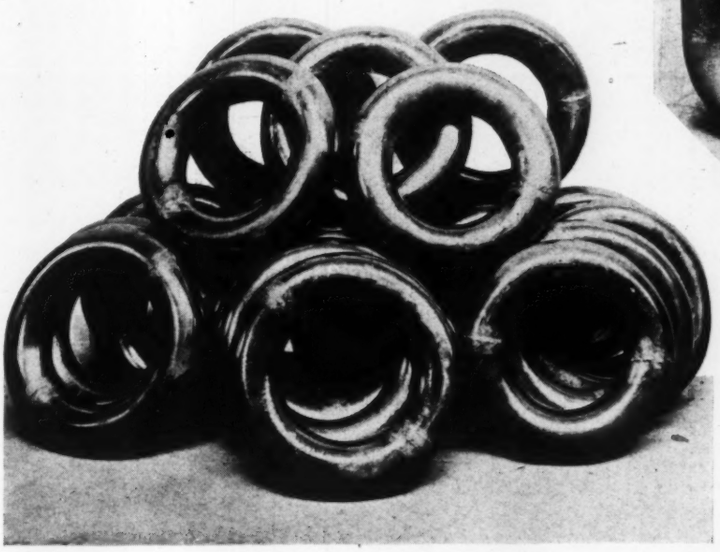
used to give warm water for domestic purposes, by the "hook up" illustrated in Fig. 1.

It is readily observed that the temperature of the domestic warm water is dependent upon the temperature of water used for heating and must be quite low when a low water temperature in mild weather is carried in the heating system.

When calling this to the attention of the steamfitter, he remarked dryly that his firm was quite aware of this condition but they expected the water to be almost all the time about 100 deg., and that this was warm enough for a bath and that for lavatory purposes it was certainly better than water at perhaps less than 40 deg. temperature. It is, of course, well known that in no European country is the public, in this respect, as exacting as in the United States.

Central Station Heating

As to central station heating, Hamburg has at the present time, by far, the largest distributing system in Europe. Exhaust steam is distributed with a pressure varying between 7.5 and 20 pounds. Steam is secured from two steam engines and in addition from a steam turbine, the generated electricity being sent into the electric distributing net of the city itself.



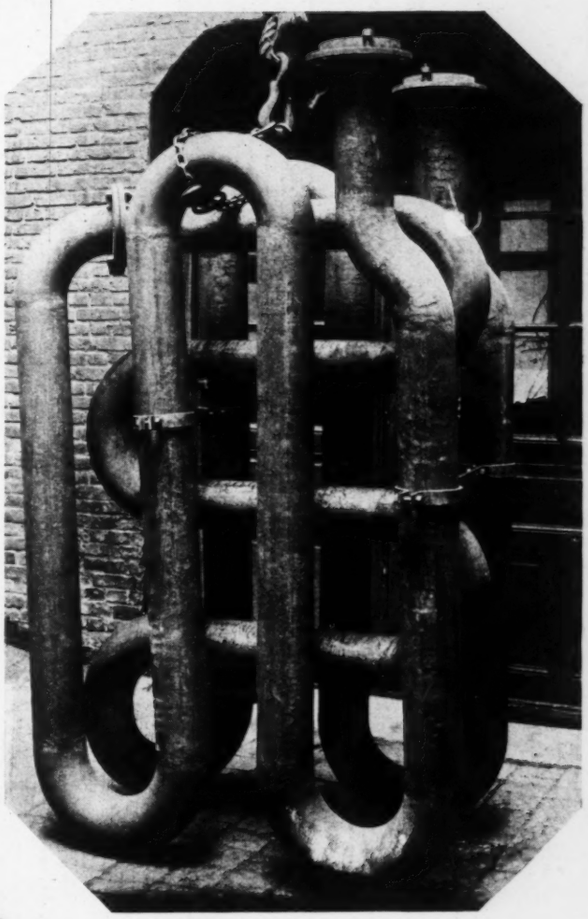


Fig. 3 and 4—Types of Welded Pipe Connections As Used in Germany

On very cold days it is necessary to add reduced high pressure steam to the exhaust steam.

All heating systems are of the gravity type and the water of condensation is returned to the power station by means of small pumps in each building.

The firm of Dr. Schiele is at present enlarging this plant, which, as far as pipe sizes and distances are concerned is rather unusual, because it is proposed to carry exhaust steam for a distance of about 3½ K.M. or 11,300 feet. The main starts with 31½ inches in diameter and connects to the present pipe system to pipe sizes of 27.5, 19.7 and 17.7 inches in diameter. It is expected that the main will eventually supply about 800,000 pounds of steam, equaling 26,000 hp. This seems, even for our conditions, a tremendous capacity in consideration of the fact that exhaust steam is distributed.

All mains, elbows, branches, etc., are welded throughout and corrugated copper expansion joints are used for these very large pipe sizes. Branches and offsets are made by bent pipes as illustrated in Figs. 2, 3, 4, 5 and 6. The pipe work is laid and welded in place. Flange joints are used only at expansion joints.

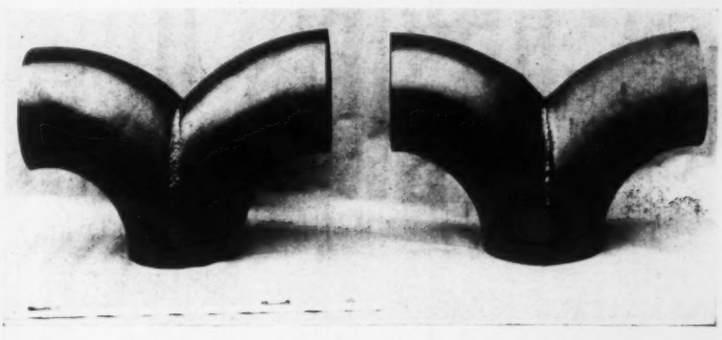
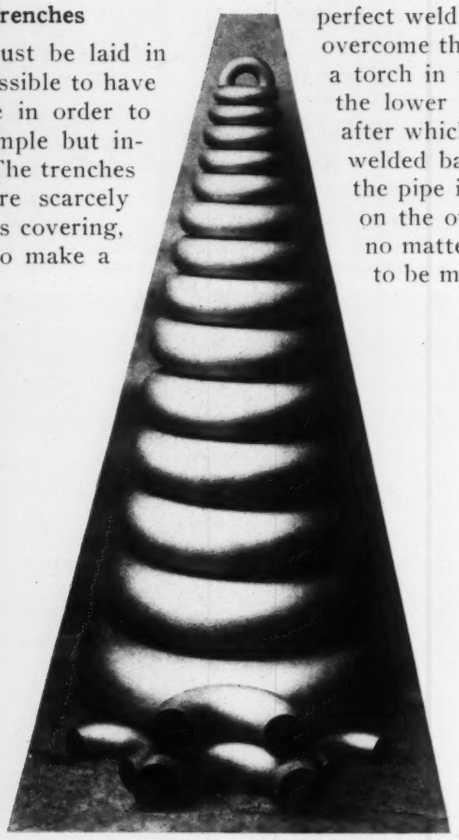


Fig. 5—Branches Are Made From Bent Pipes and Are Welded

Welding Pipe in Small Trenches

Since these large pipe sizes must be laid in places where it is practically impossible to have access to the bottom of the pipe in order to make a perfect weld, a rather simple but ingenious expedient is resorted to. The trenches in which these pipes are laid are scarcely larger than the piping including its covering, and it is therefore very difficult to make a perfect weld on the bottom of the pipe. They overcome this difficulty by cutting a hole with a torch in the top of the pipe, then welding the lower half of the pipe from the inside, after which the cut-out piece is inserted and welded back into place. The upper half of the pipe is, of course, welded from the top on the outside, which can be readily done no matter how small the trench may have to be made.



The Beresford Apartments, New York

The Beresford Apartments building, New York City, with its 20 stories, pent house and three towers is said to be the world's largest and most beautiful apartment building.

The heating equipment is upfeed with supply risers and return anchored at the fourth, eleventh and eighteenth floors. Expansion loops are concealed in the ceiling space below the eighth and fourteenth floors.

The structure is heated by low pressure steam supplied by five boilers. The pressure in each zone, of which there are two, is controlled by sub-atmospheric valves actuated by two thermostats for each zone.

Condensate is returned by gravity to the boilers.

Maintaining Reduced Pressure Against a Dead End

When no steam is being used, the reduced pressure on the outlet side of a reducing valve is likely to build up gradually until it equals the inlet pressure. Some manufacturers of steam reducing valves explain that: "This valve when used for reducing steam pressure, will not reduce against a dead end."

When a steam reducing valve is required to hold a steady and uniform reduced steam pressure, with very little or no flow through the valve, at times equivalent to a dead end, use as small a valve as will take care of the demand, arrange a reciever of suitable size on the outlet side of the valve, connect the pressure control pipe to the receiver, place a steam trap on the receiver, and if the valve has tight seats, it will maintain a steady pressure. Reducing valves will give better service if a small continuous supply of steam for some purpose can be taken from the receiver.

Factors Affecting Trap Capacity

By T. H. Rea

SUPPOSE a man were to enter a hat store and say to one of the clerks, "I wear a size 8½A shoe. Give me a derby hat that will fit just right." In nine hundred and ninety-nine chances out of a thousand the clerk would phone to the nearest institution for the feeble minded requesting it to come after one of its charges. It is almost as logical to order hats by shoe sizes as it is to buy steam traps merely by the size of pipe connections, yet this practice is still quite common even among engineers who ought to know better. No engineer would think of ordering a centrifugal pump according to shaft sizes or a turbine by weight. What he wants is a pump to handle a definite amount of water against a definite pressure head, or a turbine that will deliver a definite amount of power under fixed conditions of pressure, superheat, back pressure, etc. Why, then, not order steam traps on the basis of capacity at a certain pressure or over a definite pressure range? There just isn't any good reason except habit and lack of knowledge as to the amount of condensate to be handled and also as to actual trap capacities.

When an engineer orders an inch trap just because it will be installed on a one-inch line where a three-quarter inch trap would have ample capacity, the situation is the same as though a ton truck were purchased when a

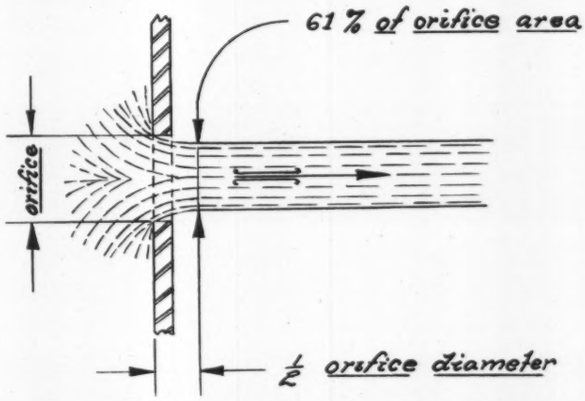


FIG. 1—FLOW THROUGH A STRAIGHT EDGE ORIFICE

three-quarter ton truck would be large enough. The first cost is higher, of course. But total cost does not end with first cost. It will cost more to operate the one-ton truck than the three-quarter ton. Likewise, the one-inch trap will radiate more heat and hence use more steam than the smaller size. Repair parts for the large trap will cost more. Even though the larger trap cost no more to operate, the advantage still would be with the smaller trap from an operating standpoint. If the trap is of the continuous flow type, in the smaller size the valve would be farther away from the seat, hence there would be less chance for wire drawing. With intermittent discharge traps, the smaller the trap the more frequent the discharge, which, in some cases, promotes good drainage.

The capacity of a steam trap, neglecting friction through the trap, is entirely dependent upon the size of the discharge orifice that the trap mechanism can open at a given pressure. After the valve orifice is opened, the pressure differential between inlet and outlet lines forces condensate through the trap orifice. Now pressure differential is fixed and hence the capacity of any steam trap (except tilting return traps which are necessarily intermittent) is the continuous discharge capacity of the trap orifice at the pressure differential indicated with no allowance for back pressure or drop in pressure through the trap.

Discharge of an Orifice

The continuous discharge capacity of an orifice easily can be figured from the formula for velocity of discharge through an orifice, viz: $V = \sqrt{2gh}$.* Given the velocity per second, the volume per second and per hour can be determined. In order to make the application of the formula perfectly clear, let us work out a typical problem. Find the theoretical volume discharge through a ½-in. diameter orifice at 100-lb. pressure differential.

Velocity $= \sqrt{2gh}$ where g = acceleration of gravity or 32.16 and h = head in feet or 100 lb. × 2.304 ft. = 230.4 ft.

Velocity $= \sqrt{2 \times 32.16 \times 230.4} = 121.7$ ft. per second.

Area of ½ in. dia. orifice in sq. ft. = .00136

Using 0.61 as the coefficient of discharge, we have .00083 sq. ft.

Area in sq. ft. × velocity in ft. per sec. = volume or .00083 × 121.7 = 0.101 cu. ft.

.101 × 62.4 lb. per cu. ft. = 6.3 lb. per sec.

6.3 × 3600 = 22680 lb. per hr.

The reason for using a coefficient of discharge is as follows; a jet of water through a straight edge orifice contracts in size as shown in Fig. 1. The distance from the orifice where the jet is smallest, hence the velocity greatest, is about one-half of the diameter of the orifice. It is at this point where the velocity of the jet is equal to $\sqrt{2gh}$ which makes it necessary to use jet area instead of orifice area in calculating orifice capacities. Rounding the inside edge of the orifice will increase the jet area but in figuring steam trap capacities, it is conservative practice to take 61 per cent of the orifice area for the jet area.

Regardless then, of the construction of a trap or means for controlling the discharge valve, a trap fitted with a ½-in. orifice cannot pass more than 22680 lb. of water with a pressure differential of 100 lb. In actual practice, friction will reduce the pressure differential and hence the capacity. However, the reduction in capacity

*The velocity of a jet of water is the square root of two times the acceleration of gravity times the head in feet. Head in feet equals gage pressure times 2.304.

due to friction is negligible compared with the effect of flash steam.

Flash Steam

In the first article of this series, reference was made to the fact that as the pressure was raised, more heat units or B.t.u. were absorbed by water before the boiling point was reached. Water at the boiling point for 100.3 lb. gage or at 338.1 deg. fahr. contains 309 B.t.u. per pound while boiling water at zero gage pressure contains only 180 B.t.u. Hence when water at 100 lb. gage and 338.1 deg. fahr. is discharged to atmospheric pressure, 309—180 or 129 B.t.u. are released. Practically all of this heat is immediately used in evaporating a portion of the water from which it was released. The percentage of condensate flashing into steam can be found by dividing the B.t.u. released by the B.t.u. required to evaporate a pound of water at the lower pressure. In this case 129 divided by 970.4 or 13.3 per cent of the total discharge by weight is changed to steam. A given weight of steam at atmospheric pressure occupies some 1650 times as much volume as a given weight of water. Assuming 100 cubic inches of water discharged at 338.1 deg. fahr., some 13.3 cubic inches would flash. The steam volume would be $13.3 \times 1650 = 21{,}945$ cubic inches. Only 86.7 cubic inches of water remain so the volume of steam is 21,945 divided by 86.7 or 253 times the volume of the water. Radiation losses quickly reduce the volume of the flash steam but the volume is always far in excess of the volume of the water discharged.

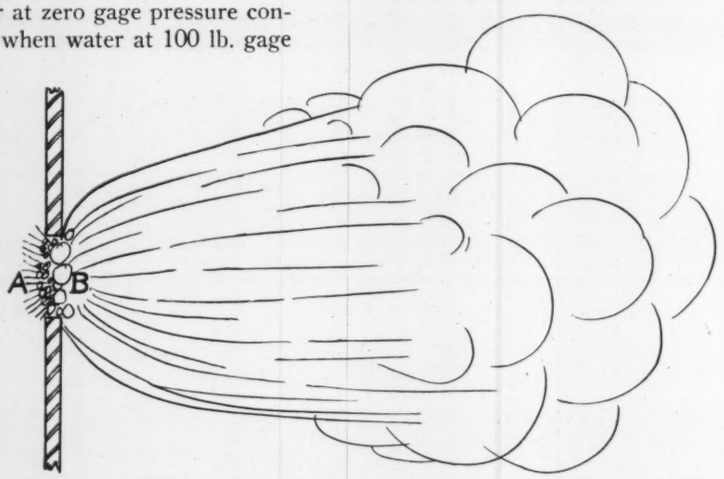


Fig. 2—The Effect of Flash Steam on Flow Through a Straight Edge Orifice

Fig. 2 represents the flow of water through an orifice at temperatures above 212 deg. fahr. Assume that the water at point *A* is under steam pressure of 100.3 lb. gage and has a temperature of 338.1 deg. fahr. At point *B* the pressure head has been entirely converted into velocity head of 121.7 ft. per sec. This pressure drop takes place in a very small part of a second giving no opportunity for heat loss by radiation; hence all the excess heat is dissipated in turning water into steam. Furthermore, some portion of the pressure drop takes place between point *A* and the orifice which means that a portion of the flash steam is generated between these points. This flash steam passes through the orifice and cuts down the amount of water that can be handled.

In actual practice, the throttling effect of flash steam is increased by back pressure built up in the discharge passages of the trap itself. Pipe friction to and from the trap will also decrease pressure differential through the trap and thus cut capacity.

Trap Installations—Emergency Service

Steam trap installations can be classified under two general heads: emergency or steam distribution system traps and process steam traps. Since steam enters the steam distribution system before it is used for process work, it is only logical that "emergency" installations be considered first.

It is highly desirable that heat losses from steam distribution lines be kept to a minimum. However, it is not possible to obtain the ideal and hence, except on superheated steam lines, condensation is bound to occur. Even superheat lines may lose their superheat and sound power plant engineering calls for a trap at every point where condensation may collect and collection points in the lines supplying steam to engines and turbines. Where water conditions are bad, it is not uncommon for slugs of water to be thrown over into the steam system. These slugs must be removed in order to prevent damage to piping and equipment.

Steam purifiers frequently are installed in the boiler just ahead of the steam outlet or in the steam line just outside of the boiler. A number of these purifiers or separators require steam traps to remove water as fast as it is separated from the steam. Separators or receiver separators are also used ahead of pumps, engines, turbines or at other points where a supply of dry steam is essential. Traps for this sort of service should be selected on a pounds per minute or pounds per second basis rather than on a pounds per hour basis. For instance on a certain job the average condensate per hour is 500 lb. However, further analysis shows that the condensate comes over in slugs and that as much as 100 lbs. per minute may come to the trap. This means that a trap with 6,000 lb. per hour capacity should be used on a job where it will not have to handle more than 500 lbs. in any one hour.

If the trap is draining a receiver separator, the size of the trap necessarily will depend not only upon the water per minute or per second but upon the capacity of the separator. In the installation referred to in the preceding paragraph, suppose a receiver separator is used that can hold 200 lbs. of water without any getting by into the steam line. Under these circumstances, a smaller trap can be used. The trap can safely drain the separator at a much slower rate than that at which the water comes to the separator.

Pipe Connections to Traps

Piston-operated traps are frequently used for emergency service, especially when the amount of water to be handled is unusually large. The discharge valves in these traps are usually the same diameter as the pipe connections. However, in order to obtain the maximum discharge capacity of the valve orifice, especially at high

pressures, pipes having larger diameters than the orifices should be used both to and from the trap. With an orifice in the line equal in diameter to the line, pipe friction, and not orifice size, limits the capacity of the trap. When the pipe size equals the orifice size, there is a big pressure drop between the receiver separator (or whatever apparatus is being drained) and the trap. This pressure drop reduces pressure differential through the trap, cutting capacity. Flash steam in the small discharge line will further reduce pressure differential and capacity.

For instance, assume a trap on the end of a thirty-foot line having four elbows and 400 lb. gage pressure at the receiver. With a 2½-in. valve in a 2½-in. line, pipe friction would hold the capacity to 101.6 cubic feet per minute while the trap could handle 216 cubic feet per minute. A 2-in. trap in a 3-in. line could handle 140 cubic feet per minute while the line itself, without a trap, can pass 177 cubic feet per minute. In the first case, the 2½-in. pipe limits the 2½-in. trap to 101.6 cubic feet per minute while the 3-in. line allows a smaller trap to handle 140 cubic feet in the same time.

Traps for separator service are seldom called upon to work to capacity, in fact, on superheat jobs they have practically nothing to do except when steam is first turned on or in an emergency.

If no separators or purifiers are used on a steam distribution system, traps draining steam headers and drips should have the same characteristics and should be selected on the same basis as traps for separator service, i.e. large enough to handle condensate or slugs of water just as fast as they come to the trap.

The third article of this series will appear in an early issue.

Review of Draft Proposals for American Standards

An essential part of the procedure of the *American Standards Association* is its distribution of copies of the preliminary drafts of proposed standards for criticism and comment. Accordingly, each proposed standard for which the Society is sponsor or joint sponsor is set in type when it has been released by the subcommittee which developed it and from 100 to 300 copies are mailed to a list of individuals who are known to be interested in this proposal and willing to assist the committee by giving it the benefit of their knowledge and experience bearing on the standard in question.

The *A. S. M. E.* Standardization Committee believes that in each of the Society's local sections there are those who would welcome an opportunity to review these standard publications in their tentative form. It accordingly proposed to the Committee on Local Sections that the names of the secretaries or some other officer of the 71 local sections be added to the permanent mailing list of the *A. S. M. E.* Technical Committee Department and that these officers assume the responsibility of placing the proof copies in the hands of one or more local men best qualified to review and write a criticism of the proposed American Standard. The Committee on Local Sections approved this proposal and a start has been made in establishing this procedure.

It is altogether possible that certain of these proposed standards may be of sufficient interest to the members of a local section that the officers would be justified in arranging for the presentation of reviews of them at the meetings of the section. The responsible officer is urged, however, to forward the comments of the individual member or small group to the *A. S. M. E.* headquarters within two weeks of their receipt and to send the abstract of the discussion at the meeting as soon as possible after the meeting date.

The *A. S. M. E.* Standardization Committee is willing to send a copy of the standard in its final pamphlet form to each and every local section which submits a carefully prepared critique.

Mechanical Standards Advisory Council

A significant development proceeding from the activity of the *American Standards Association* is the organization of the *Mechanical Standards Advisory Council*. There are many organizations, both societies and trade associations, which, while vitally interested in the *A. S. A.* and its procedure, are not able to undertake the financial obligations of membership in the *A. S. A.* For these and all the organizations which serve the mechanical industries the *M. S. A. C.* was formed.

The present plans call for meetings of official representatives of the organization members of the Council at stated intervals about six months apart at which problems relating to the questions—what and when to standardize in the mechanical industries—will be discussed. These questions have a decidedly important economic bearing on these industries. The magnitude of the task and the limited personnel make a need for the systematic approach and development of standardization projects imperative. The functions of the *M. S. A. C.* are accordingly framed as follows:

1. To endeavor to obtain, at the request of any interested group, the desired co-operation of organizations in any standardization project in the mechanical field;
2. To confer with any organization in the mechanical field interested in or carrying on work which eventually may be presented for action under the Rules of Procedure of the *American Standards Association;*
3. To advise the *American Standards Association* on questions of policy relating to standardization applying to products of the mechanical industries;
4. To serve as a general co-ordinating medium in the mechanical field, within the scope of the Constitution, By-Laws and Rules of Procedure of the American Standards Association;
5. To consider—
   a) the desirability and practicability of standardization projects within its field,
   b) the order in which Standards shall be developed,
   c) the scope of projects,
   d) sponsorships for the necessary Sectional Committees, and
   e) the adjustment of conflicts and the clearing up of ambiguities; and
6. To follow up and expedite work in the development of standards.

—*A. S. M. E.*

Drying and Temporary Heating of Large Buildings

By John Howatt

THE factor of overhead is one that very frequently determines whether a business shall be a failure or a success, and any business, whether it be a success or a failure, will achieve greater success and will attain a better position to withstand storms and turbulent times if its overhead can be reduced to a minimum. An industry that is compelled to earn all of its profits by operating within a part of the year only must look for ways and means of extending its activities throughout the twelve months of the year before it can hope to succeed in the biggest way, for any business that is busy for a part of each year and practically idle for the remainder of the year must, of necessity, have to bear an excessive burden of overhead. It is for this reason that coal mine operators urge the purchase and stocking of coals in the warm summer months, railroads urge the same thing to keep their freight cars and locomotives busy in the July and August months before the movement of crops begin, and retail coal merchants establish combination building material and coal yards to keep their trucks and equipment in service the year around. There are many other examples of industries trying to reduce their overhead by keeping their organization busy the full year.

Taking the Seasonal Factor Out of the Building Industry

At one time the building industry was, more or less, a seasonal occupation. Building activities formerly were confined very largely to the summer months. For a number of years past, however, builders have increased the efficiency of their organizations and have reduced their burden of overhead by constructing buildings, even in northern climates, during all twelve months of the year. Winter building of large structures is now just as extensive as summer building; it has made necessary, of course, provision for warming and drying the buildings as soon as they have been closed in.

The most generally used means of warming and drying large buildings is the installation and maintenance of temporary direct radiation throughout the building and the operation of the boiler heating plant. In smaller buildings the heating is sometimes done with salamanders, burning coke as fuel, but labor union regulations in many cases prohibit the warming of buildings by this means, and properly so, because burning coke in open salamanders in a closed building results in an air condition in the rooms due to the presence of the products of combustion, which may be unhealthful to say the least.

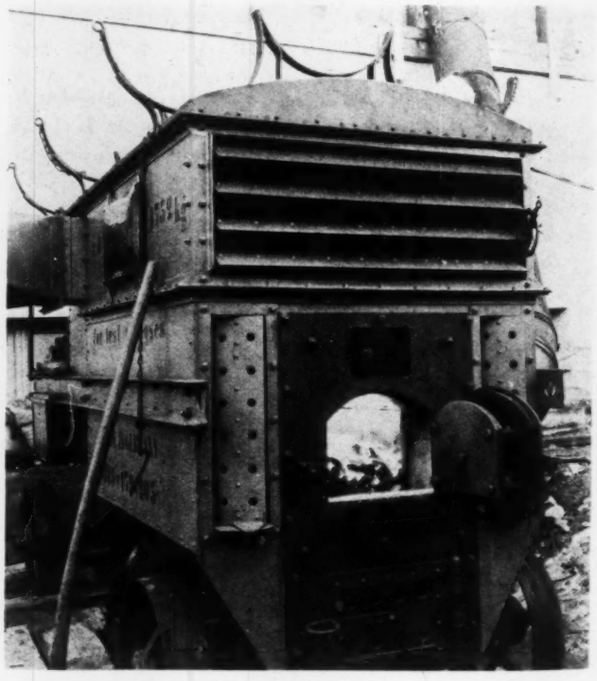
Quick Drying Speeds Up Construction

The greatest demand for heating and drying the new buildings comes when the walls are first plastered. At this time a great deal of moisture is introduced into buildings by the application of the wet plaster and, ordinarily, the drying processes during the winter months are very slow. The application of wood trim, floors, painting, decorating, etc., must be delayed until the plaster is thoroughly dried so that the woodwork will not expand and buckle out of shape. It is, therefore, desirable from the standpoint of speeding up construction to dry out the building quickly. The application of heat either by temporary direct radiators or, as in some small buildings, by salamanders, while it results in warming the building does not necessarily give sufficiently rapid drying action because the air in the building soon becomes saturated with moisture.

All of the new school buildings built in the city of Chicago are equipped with mechanical ventilating systems which provide air movement in every space throughout the building. As soon as a school building is closed in and ready for plaster, the contractors installing the heating and ventilating apparatuses are called upon to complete the equipment to a point where it can be used in warming and drying the building for other crafts.

Some Fundamental Principles of the Drying of Plaster

The drying of a coat of plaster on a wall of masonry takes place by evaporation at the surface of the plaster. If the air at the surface of the plaster is saturated with

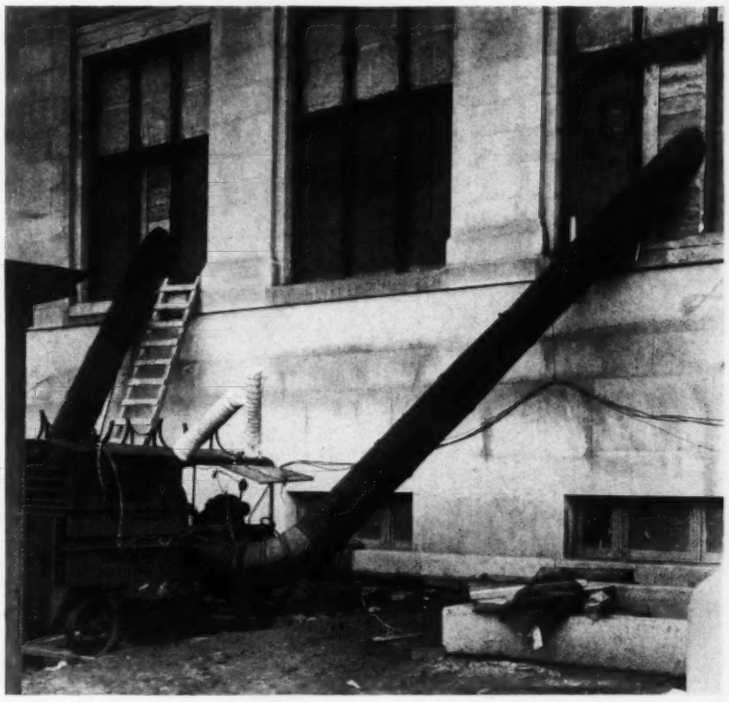


A Close-up of the Equipment Used in Drying Buildings On Which Tests Were Made

moisture, no evaporation can take place. It, therefore, is necessary that there be an air movement to remove the saturated air from the room and replace it with dryer air ready to take up moisture from the surface of the plaster. When heat only is provided, air movement is accomplished by opening windows. It is necessary for the water in the interior layers of the masonry and plaster to work through to the surface. As the plaster at the surface is dried, the moisture on the inner layers is drawn toward the surface by the capillary attraction of the porous materials. The rate of drying, therefore, must depend upon:

1—The rate of transfer of moisture from the interior layers of the plaster and masonry to the surface.

2—The capacity of the air to take up and carry away this water in the form of vapor.



THE FAN DELIVERS THE HEATED AIR OVER THE FIRE AND THROUGH DUCTS TO THE BUILDING

The rate at which the water can be brought from the interior layers to the surface depends upon the porosity of the material itself and the condition of the surface. The capacity of the air to take up and carry away moisture depends upon its relative humidity, its temperature and its movement over the surface. Air at any given temperature has a definite capacity for taking up moisture. The ratio between the amount of moisture which air contains at any given temperature and the quantity it could contain if fully saturated, is known as its relative humidity, and relative humidity is one of the factors determining the rate of drying; the lower the relative humidity, the more rapid the drying; with humidity 100 per cent, the drying effect is zero. Air movement over the surface is necessary in order to replace the saturated air with air of relatively low humidity, ready to take up moisture.

The evaporation of water from the surface of the plaster requires heat. The total heat required for the latent heat of evaporation is 971.7 B.t.u. per pound of water. This heat can be most readily supplied and controlled by regulating the temperature of the air in the room. As evaporation takes place, the air at the surface of the plaster tends to become saturated and cool. In order for evaporation to continue, this cool saturated air must be removed and replaced by fresh warmed air of low relative humidity. In order to control the rate of drying of the plaster and masonry, therefore, it is necessary to maintain a constant circulation of warm dry air throughout the spaces, the rate of evaporation being determined by the relative humidity, the temperature and the movement of the air in the rooms.

Setting of Lime Plaster

The aging and proper setting of a coat of lime plaster or of mortar involves both a drying and a chemical change. As applied to the wall, the lime in plaster is in the form of calcium hydroxide. When this material is setting it reacts with the carbon dioxide in the air forming calcium carbonate and giving off water. It is seen, therefore, that carbon dioxide in the air is necessary for the proper setting of lime plaster. The usual amount in air serves the purpose. The amount of water formed in the conversion of calcium hydroxide into calcium carbonate is negligible as compared with the water added to the plaster mixture to make it plastic. The rate at which this aging and setting can be accomplished depends somewhat upon:

1—The rate in which carbon dioxide can be brought into contact with the calcium hydroxide, not only on the surface of the plaster but also throughout the entire thickness of the coat.

2—The drying out of the water formed in this reaction and other water by the means discussed above.

High Porosity of Building Materials

The high porosity of even the solid forms of plaster has been thoroughly established. A notable example of the porosity of building materials is illustrated in the tests made by the Bureau of Standards and by the research laboratory of the *American Society of Heating and Ventilating Engineers* for heat transfer through various building materials where it is found necessary to shield a wall of solid brick with steel plate to prevent infiltration due to wind. The pressures through a building by reason of the difference in temperature between the inside and the outside, wind pressures, etc., will frequently cause infiltration through the porous building materials at a rate rapid enough to furnish an air movement which will provide for the evaporation of the moisture from the surface of plaster and masonry walls when heating only is provided.

Danger of Drying Plaster Too Rapidly

In fact, it is quite possible to dry plaster too rapidly. Drawing the moisture out of it before the chemical changes have taken place may result in the checking and

crumbling of the plaster with a loss of mechanical strength and a non-uniform condition within the material. Everyone has seen the builder in residence work during the hot months of July and August wet the wood lath before applying the plaster, to keep it from drawing moisture too rapidly from the plaster, and even spray the walls with water afterward to prevent the plaster from drying before it has become properly set. Generally, we have the builder on the one hand anxious to dry the plaster as rapidly as possible, and the consideration of the quality of the plaster on the other which demands a slow uniform drying period.

Amount of Heat Required to Dry Plaster

The amount of heat required to dry the plaster in a building, considering the latent heat of evaporation alone, is a great deal more than most persons imagine. It is estimated that there are approximately 8 lb. of water in every 10 sq. ft. of green plaster of ordinary construction. This means that 7,800 B.t.u. of heat must be furnished to evaporate the moisture in 10 sq. ft. of plaster in addition to the heat required for warming the building. Many of our school buildings being built in Chicago today have in excess of 800,000 sq. ft. of plastered surface. This means 640,000 pounds of water must be evaporated requiring the furnishing of approximately 622,000,000 B.t.u. of heat for drying out the water added in preparing plaster alone in a building of this size.

New Equipment to Speed Up Drying

A new piece of equipment designed to speed up the drying operation in new building construction without detriment to the quality of the plaster was developed in Germany and tested out this year under American building conditions during the construction of Langwell Hall at Harvard University, Cambridge, Mass. This equipment is a heater mounted on a truck trailer body so as to be readily portable from building to building. The heater equipment consists of a fire box suitable for burning coke and so arranged that a fan can draw air over or through the fire and deliver it through ducts into the building under construction.

A test was conducted to compare the efficiency of this equipment with the conventional installation of temporary radiation. Two rooms were selected immediately after plastering, and the one served by this equipment was isolated from the remainder of the building. Results of the tests were as follows:

Character of Test of Drying Equipment

The test was run for about seventy-two hours. The plastering in the room to be tested, which is represented in the table as room *A*, was completed the day before the test was started. Records were also kept in room *B* where the plastering had been completed only a day or two before that in room *A*.

Room *B* was heated by the conventional method of temporary radiation.

The following records were kept: outdoor temperature, temperature of room *A*, temperature of room *B*, temperature of air at fan outlet, relative humidity in room *A*, relative humidity in room *B*, the amount CO and CO_2 in room *A*.

The amount of air delivered by the fan to room *A* was measured twice during the test period. These data are shown in the table on this page.

Results of the Test

It will be seen from the table that the temperature in room *A* held fairly constant at slightly over 100 deg. fahr. after the first day, it having been raised gradually. It will also be seen that the relative humidity in the room was very low and that there was a pressure in

Test Results of Drying Equipment

Day	Time	Elapsed Time	Temperatures of				* % CO	** $\%CO_2$	Room *A* Pressure Inches of Water	Relative Humidity %	
			Outside	Room *A*	Room *B*	Fan Outlet				Room *A*	Room *B*
First Day	2:45 p.m.	.....	.....	60.3	.....	.....	.....	.....	.....	78	.....
	3:25 p.m.	0.7 hrs.	54	86	.....	122	none	.....	.....	34	.....
	3:45 p.m.	1. "	52	87	67	.....	"	.16	.16	36	.....
	4:20 p.m.	1.7 "	50	83.5	68	.....	"	.....	.14	41	.....
	8:25 p.m.	5.7 "	40	90	71	122	"	.212	.14	33	61
Second Day	9:50 a.m.	19. "	56	102	70	144	none	.25	.....	25	.....
	10:15 a.m.	19.5 "	56	105	.....	135	"	.....	.....	22	.....
	2:40 p.m.	23.9 "	48	101	66	122	"	.232	.....	20	44
	3:20 p.m.	24.6 "	46	101	.....	149	"	.....	.08	20	.....
	7:35 p.m.	29. "	37	102	71	145	"	.34	.07	21	.....
	10:45 p.m.	32.2 "	32	115.5	72	153	"	.24	.10	15	43
Third Day	9:40 a.m.	43. "	40	108	71	144	none	.248	.08	18	.....
	4:20 p.m.	49.7 "	37	110.5	70	144	"	.....	.09	11	.....
	5:40 p.m.	51. "	36	114	69	145	"	.395	.10	13	29
	11:25 p.m.	56.8 "	32	102	68	131	"	.....	.14	11	30
Fourth Day	9:25 a.m.	66.8 "	32	112	66	165	none	.37	.17	10	37
	1:40 p.m.	71. "	35	99	66	.....	"	.36	.16	13.5	.....

* Carbon monoxide—Toxic.
** Carbon dioxide—normal amount 0.04%.

the room varying from .07 to .17 in. The pressure was reduced the second day as recommended by the builders of this machine.

The table also shows that the temperature in room *B* which was heated by steam radiators was constantly around 70 deg. fahr., but that the relative humidity was much higher than in room *A*.

These differences in temperature and humidity together with the rapid air changes in room *A* account for the rapid drying of the plaster in this room. After being heated three days room *A* was dry enough so that the plaster could have been painted at once.

The air in room *A* was analyzed frequently to determine presence of carbon monoxide, CO, which is very poisonous and of carbon dioxide, CO_2, which is not poisonous, and which is essential to the hardening of lime in lime plasters.

The results of the analysis showed no carbon monoxide. Carbon dioxide varied from 0.16 to 0.39 per cent. No test for sulphur dioxide (SO_2) was made. The quantity of this gas would depend entirely upon the sulphur content of the coke used for heating. Neither of these latter two gases, CO_2 or SO_2, were present in quantities such as to be injurious to persons working in the room.

Advantages of Drying with High Concentrations of Carbon Dioxide

Under the conditions of the test, due to the porosity of the plaster, there would be a slight air movement through the plaster from inside to outside except where those walls are under a wind pressure exceeding the pressure within the building. Such air thus forced through the plaster in the application of this apparatus must carry with it an abnormally high concentration of carbon dioxide resulting from the products of combustion in the coke fire in the equipment into immediate contact with the calcium hydroxide in the plaster coat and speed up the chemical changes. Any equipment that will fill a building with warm air of abnormally high carbon dioxide content under pressure, must offer some advantages in the rate of drying of lime plaster over an equipment which maintains only a fixed temperature in the space to be dried. However, all mechanics would, of necessity, have to leave the space being dried while the process is going on as no one would work in a space into which gases of combustion from a coke fire were being fed.

It is probable that equipment of this kind will find its use for special building conditions rather than for general use in office building construction. In any event, means must always be provided to remove the moisture taken out of the plaster from the rooms whether that moisture be the water added to the mixture in preparing it or whether it be the water formed in the conversion of calcium hydroxide into calcium carbonate. Our old friends, temperature, humidity and air movement, must again be recognized as the controlling factors.

Inspecting Reducing Valves

When inspecting a steam reducing valve that is not supplying enough pressure, first see that the supply valve is wide open, and be assured that there is no restriction or obstruction between that valve and the boilers; make sure the interior disc of the steam supply valve is not off the stem or wedged so as to restrict the flow of the steam, and test the pressure gages for accuracy before dismantling the reducing valve.

Do not operate a reducing valve by throttling the supply valve and by trying to adjust this valve by hand to get the required regulation and control of the delivery pressure. Open the supply valve wide, find out what is the matter with the reducing valve and make it do the work.

First Stackless Building Erected in Chicago

The new 40-story home of the Foreman National Bank in Chicago, illustrated here, is the first skyscraper in that city to be built without a smokestack. The building is heated from the boilers of the adjoining Conway Building.

The Phillips, Getschow Company, Chicago, provided for certain changes in the heating plant of the Conway Building whereby the exhaust steam could be passed through an 18-inch steam pipe from the boiler room of that building into the sub-basement of the

Foreman building. The engineers have provided for the use of surplus heat from excess exhaust steam and claim that it will not be necessary to burn additional fuel in order to supply the heating system for this new skyscraper.

Improved Electrical Properties by Drying

Article No, 2

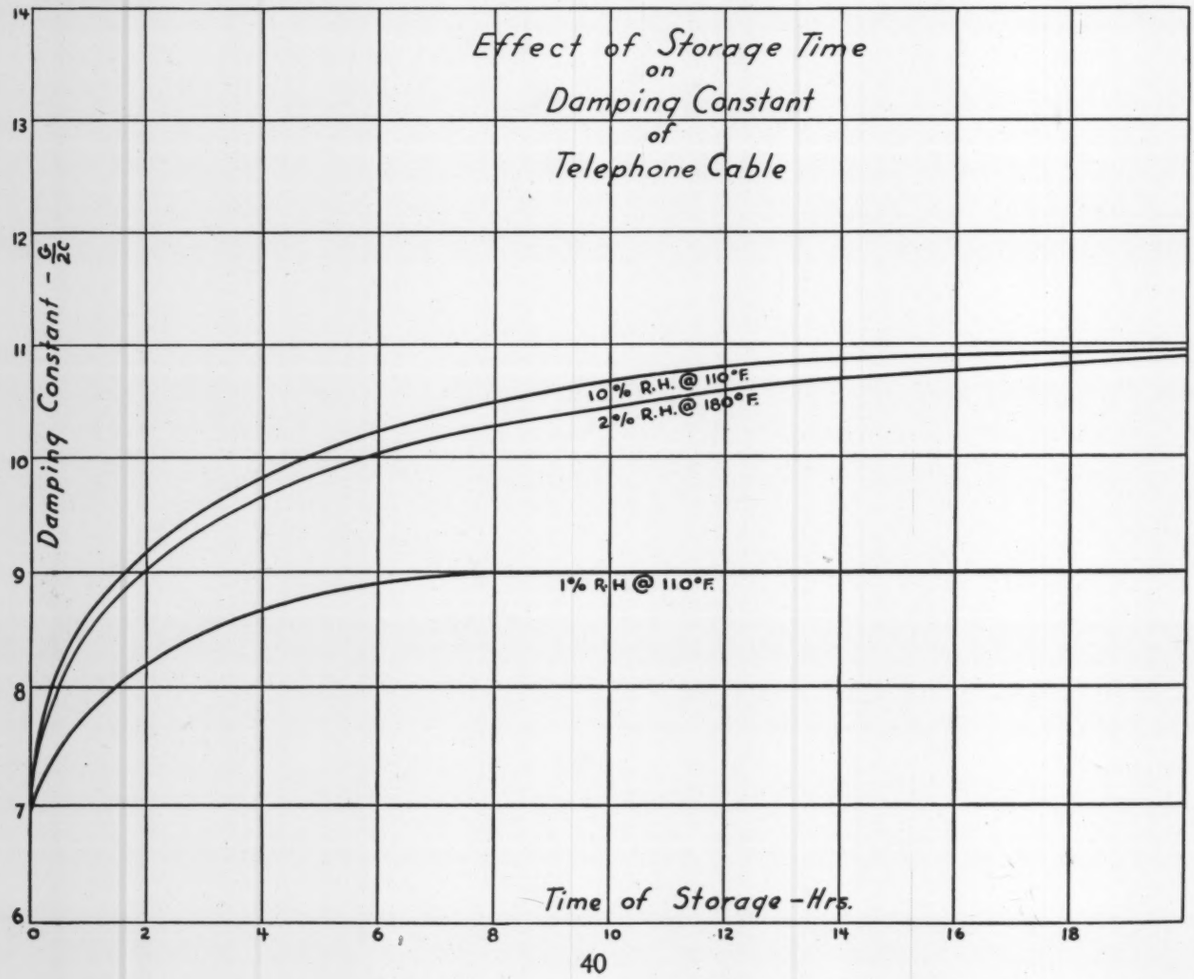
By R. F. Morrison

IN THE previous article on improved electrical properties by drying, published last month, the practical value of the damping constant $\frac{G}{2C}$ for dry core paper telephone cable at 15 deg. cent. was given as 9.0. This was the value desired for lead-covered long distance, or toll, cable. At rare intervals it might be lower but, in general, it was higher. When values from 10.0 to 15.0 were obtained for a given cable length, extra loading was needed for that length in order to secure the desired line inductance and attenuation.

Where vacuum drying of cable cores was had at a temperature of 250 deg. fahr. and an absolute pressure of ½ lb. per sq. in. the effect of the vacuum period and also of the storage period which followed can be seen readily in the three curves shown in Fig. 1. In one curve the storage room was maintained at a relative humidity of 10 per cent while in the second it was one per cent. In both of these cases the storage room temperature was 110 deg. fahr. The third curve is based upon a relative humidity of 2 per cent at a storage room temperature of 180 deg. fahr. These curves are, of course, approximate, as they would vary for the size, type and length of cable, with the tightness of the paper on the cable, with the number of thicknesses of cable on the core truck, with the variation in the relative humidity in all parts of the storage room and on several other factors.

It would be well to bear in mind that the results shown are minimum for the conditions named as there are many difficulties to be surmounted, between the lead sheathing and the testing operations, which can adversely affect the factor

FIG. 1



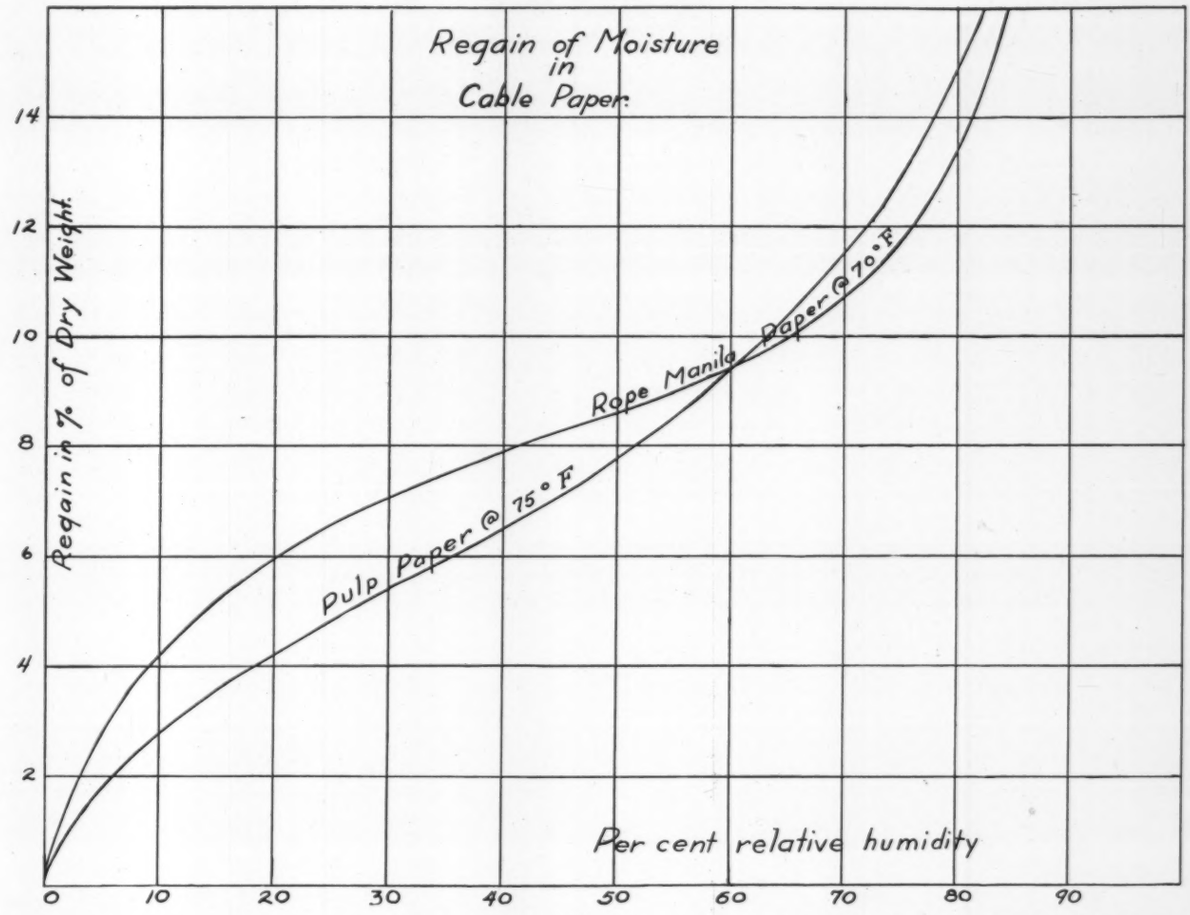


FIG. 2

$\frac{G}{2C}$. The data submitted, while they do not cover identical types and sizes of cable, serve to illustrate the effect of storage, under atmospheric pressure at a fixed humidity, on the damping constant of telephone cables and, because $\frac{G}{2C}$ is so vitally affected by moisture, they show how rapidly the paper insulation of the cable core approaches equilibrium with the surrounding air-water vapor mixture. It is also interesting to note how quickly the one-per cent curve comes to equilibrium while the other curves have not approached equilibrium at the end of 20 hours.

Regain for Paper Insulation

In Fig. 2 is given the moisture regain curves for papers used in the manufacture of telephone cable. Both of these curves show that, from a drying standpoint, it is important to use very low relative humidities in the storage of cable cores after they have been dried.

Since the capacity of the telephone cable is held practically constant it can be said to be one of the factors of cable which is fixed. The mutual capacity varies, in lead-covered, paper-insulated telephone

With radio as well as with the telephone, the object sought is the transmission of speech and music. To accomplish this end, distortion must be reduced to a minimum. This means that the constituent harmonics must not be displaced in phase or amplitude. Improvement in each of the two types of equipment under consideration is dependent upon quality of materials and parts used. Moisture is one of the greatest enemies of quality and partial removal, once thought satisfactory, is now known to give results which cannot meet with approval.

We have noticed the adverse effect of dust which can so readily be eliminated with air washers. It has been shown how better drying methods will so improve the characteristics of the telephone that fewer loading coils are required. It has also been shown that radio can benefit by the use of drying methods which have been successful for telephone cable. It is apparent that other electrical equipment may be benefitted by similar changes in drying. It is also apparent that very sensitive electrical equipment will operate with better results in an atmosphere which is kept dry by air conditioning.

cables, between 0.070 and 0.085 microfarads per mile depending upon the type and size of the cable. Since this factor varies to such a slight degree it becomes apparent that the conductance, which is actually the reciprocal of the resistance, and the insulation resistance are the two factors which are greatly affected by the presence of moisture. The data so far furnished indicates just how markedly the conductance is affected.

Previous to the advent of modern drying methods in the manufacture of telephone cable, the insulation resistance varied greatly, especially with the season of the year. While a value of 1000 megohms per mile was considered satisfactory it was also thought desirable that values between 10,000 and 20,000 megohms per mile be attained. In highly humid periods of the summer it was not unusual to reject a number of cables as their insulation resistance was below 1000. When the relative humidity of the storage room had been decreased to ½ per cent from 10 per cent and when the vacuum obtained in the driers had been lowered from 1 to ¼ lb. per sq. in. absolute, the insulation resistance, as well as $\frac{G}{2C}$, rose to new levels with a smaller gap between the minimum and maximum values obtained. This means more than is apparent in the statement made, since a certain amount of the variation in these factors could always be accounted for by the moisture picked up by the ends of the cable, which were bared on the test floor, and by the cable core itself during the sheathing and cooling periods prior to the final tests. Under the new conditions, the insulation resistance varied from 5,000 to 25,000 megohms per mile, with rare exceptions.

In the production of radio receivers the condenser, which is considered the most sensitive part of the equipment, is dried by vacuum and impregnated at the end of the vacuum period. For a capacity of 1.0 microfarad it is usually considered good practice when the insulation resistance is 10,000 megohms. Most impregnating compounds are crystalline in structure and are, quite naturally, easily cracked. Furthermore, they are affected by temperature, under normal conditions, which results in separation of the grain structure. In this way moisture can find its way through to the insulation. It therefore seems possible that much better electrical characteristics can be had in this field when better drying methods are adopted. This would undoubtedly mean better vacuum, in the vacuum drying process, accompanied with low humidity air conditioning or the use of air conditioning, alone, at low humidities.

"Open for Discussion"

A department in which we follow the custom of technical societies of allotting space in their programs for discussion of the papers presented

AIR CONDITIONING IN ITS RELATION TO HUMAN WELFARE

A discussion by Major S. Munson Corbett, Medical Inspector for Public Buildings, Washington, D. C., and F. C. Houghten, director of A. S. H. V. E. Research Laboratory, Pittsburgh.

Tests on Air Conditioning for Comfort. Major S. Munson Corbett

IN connection with my work as medical inspector for public buildings and public parks of the national capitol, a series of tests were conducted to ascertain whether improvements could not be made in the modern methods of air conditioning or air rectifying in its relation to human welfare which would serve as a guide in the selection of new equipment for the maintenance of the highest quality of air possible in the new government buildings now in the process of construction. The tests are timely inasmuch as the present building program of our government is probably the most extensive the world has ever known.

With this in mind, suitable equipment was installed in one of the permanent government buildings and elementary tests were conducted to demonstrate the value of adding moisture in certain cases to heated air and to test the efficiency of certain types of air rectifying devices. During these tests, the comfort tables as adopted by the *American Society of Heating and Ventilating Engineers* were considered carefully and it is in this connection that I wish to express an opinion that differs radically from the accepted standards. These tables are quite satisfactory from the standpoint of comfort but I feel that they are incorrect from a physiological or health point of view.

Major Corbett's Conviction as to Humidity and Its Relation to Human Welfare

It is my conviction that humidity should be maintained in direct relation to the rise in temperature; that, as we elevate the temperature, we should also increase the humidity. The comfort tables are based on the principle that temperature, plus evaporation, equals body comfort; that is to say, if we raise the dry bulb temperature we must lower the humidity in order to increase the evaporation from the body. This is true and is satisfactory from a practical viewpoint if we consider only heat loss as it relates to comfort. However, from the physiological or health aspect, I feel that it is undesirable to dehydrate the body tissues beyond a certain point in order to produce the necessary heat loss required to maintain body comfort at high temperatures. When the body is subjected to low wet bulb and high dry bulb temperatures, very definite and apparent reactions take place such as drying of the mucous membranes, increased tendency to

respiratory infections, increased irritability of the nervous system, et cetera. As moisture is added to the air, these reactions seem to decrease.

In my opinion, we should maintain a relatively low dry bulb temperature with a fairly high percentage of moisture, between 30 and 50 per cent, which ratio should be maintained regardless of the dry bulb temperature. In other words the "drying action of the air" on the body tissues should be kept fairly constant and if, in certain cases, it is necessary or desirable to elevate the dry bulb temperature, more moisture should be added to maintain the proper relative humidity. I feel that to lower the moisture content of the air when the dry bulb temperature is elevated, in order to produce the heat loss necessary to make such temperature comfortable, is wrong. I am convinced that this principle should govern in rectifying air and that research will prove that somewhere along the scale of wet and dry bulb temperatures there is a ratio better suited to promote the normal physiological activities than are now accepted as standard.

Our tests are as yet incomplete so that no conclusions can be made at this time. However, they lead me to believe that every home or public building should be provided with some type of hygrometer in order to check the wet and dry bulb readings unless it is taken care of automatically by some approved type of air rectifying equipment. What is needed is a simple, inexpensive and satisfactory type of hygrometer, although there are types which can be read with very little practice and calculation.

We know that certain combinations of humidity, temperature and air motion as found in most southwestern areas afford relief from respiratory affections, especially those involving the upper air passages, for example, affections of the sinuses of the nose, inasmuch as patients suffering from these conditions in our eastern atmosphere are often afforded relief when reaching the southwest. In this region while the humidity is relatively low, it never reaches the dry point of heated buildings.

Conclusions

It appears that air should be rectified so that the loss of body moisture through the air and the increase in dry bulb temperature should be a fairly constant factor. It is my belief that a proper formula which involves temperature, humidity and air motion can be made adaptable for both home and office use. Certainly it seems essential at this stage of development of the science of air rectification, that both medical and engineering authorities co-operate in the production of correct tables which are satisfactory from the physiological standpoint as well as the mechanical standpoint, which seems to be the basis of the present comfort tables.—Major S. Munson Corbett.

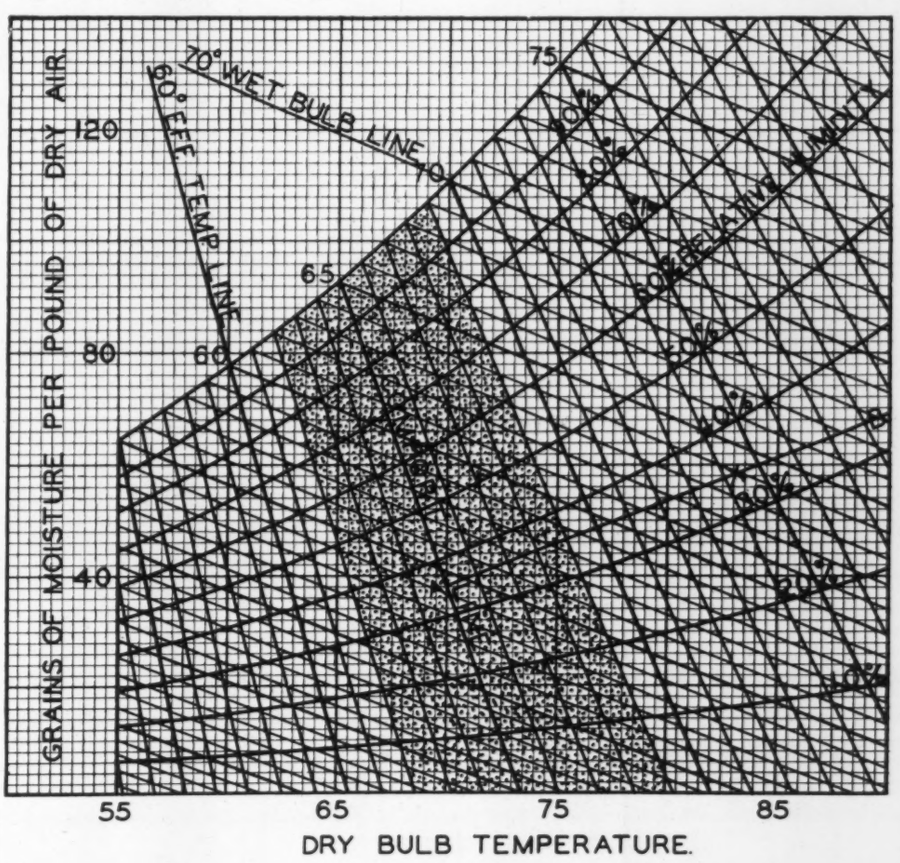


FIG. 1—PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR STILL AIR CONDITIONS, PERSONS NORMALLY CLOTHED AND SLIGHTLY ACTIVE. THE SHADED AREA INDICATES THE COMFORT ZONE

Comments by F. C. Houghten

The discussion of "Air Conditioning in Its Relation to Human Welfare" by S. Munson Corbett, major, medical corps, U. S. Army and medical inspector for public buildings is most timely and considers questions of vital importance to the air conditioning engineer at this time.

There are three main points discussed or analyzed by Major Corbett which are of particular interest to the air conditioning engineer and the research laboratory of the *American Society of Heating and Ventilating Engineers* in the study of the relation of man to his atmospheric environment. These three points are:

1. Statement by Major Corbett in the conclusion to his paper:

> "It is my belief that a proper formula which involves temperature, humidity and air motion can be made adaptable for both home and office use. Certainly it seems essential at this stage of development of the science of air rectification, that both medical and engineering authorities co-operate in the production of correct tables which are satisfactory from the physiological standpoint as well as the mechanical standpoint."

2. Statement by Major Corbett in the body of his paper:

"Our tests . . . lead me to believe that every home or public building should be provided with some type of hygrometer in order to check the wet and dry bulb readings unless it is taken care of automatically by some approved type of air rectifying equipment."

3. A discussion of the application of the comfort line and comfort zone as determined by the research laboratory as representing optimum conditions for health and a statement of his belief that these lines while true lines of equal comfort are probably not lines of optimum health throughout their length. High temperatures with extremely low humidities while giving proper feeling of warmth are probably not desirable from a health point of view.

A Need Long Recognized by Engineers

It is most gratifying to the air conditioning engineer to find a medical man of such high authority recognizing the need of establishing standards of air conditions which will be most conducive to health and comfort of man. Too often, the medical man, while showing an interest in atmospheric conditions, has limited his interest to the type of equipment or lack of equipment which was supposed to produce the proper atmospheric conditions rather than place the criterion of proper air conditions on the physical and chemical qualities of the air itself. Major Corbett states well a need which has long been recognized by the engineers of the *American Society of Heating and Ventilating Engineers,* and which more than anything else was the reason for establishing the research laboratory.

Point No. 1

Quite a number of years ago we find from the records of the society the following statement coming from Fred Still, a very prominent air conditioning engineer—"if only the medical profession will write the prescription for air conditions most conducive to the health and comfort of man, the engineer stands ready and willing to fill that prescription." Major Corbett's position and authority promises much in the way of helpful co-operation between the engineer and the medical man.

Point No. 2

The second point made by Major Corbett recognizes the need for control of more than the dry bulb temperature for proper air conditioning in our homes and public buildings. This is, of course, in direct harmony with the expressed views of the *American Society of Heating and Ventilating Engineers.*

Point No. 3

The third point mentioned above as contained in Major Corbett's paper is a discussion of a very vital phase of the entire question of the relation of man to his atmospheric environment and one which has long been recognized by the research laboratory of the *American Society of Heating and Ventilating Engineers.*

While the laboratory has every confidence in the effective temperature lines as established in its various laboratory reports as being true lines of equal feeling of warmth, it has always recognized them as essentially equal comfort lines. There always has been doubt on the part of those interested in the subject as to whether or not all the air conditions represented by points throughout the length of the comfort line were conducive to health and comfort. While the laboratory constantly has had before it the desirability of making a study of the relative values of various points throughout the length of the comfort line from a health point of view, it never has been successful in planning a study which would give the desired information. It probably will involve a study in which the medical research man and his methods rather than the physical research engineer will be most successful.

Fig. 1 is a small psychrometric chart covering the region containing the comfort zone and the comfort line. While every point on the comfort line will give the same relative feeling of warmth to a person, there is considerable doubt whether or not the extreme upper and lower portions of this line are desirable for the health of man. In fact, the ventilation standards of the society have only recognized the portion of this line between about 30 and 60 per cent relative humidity as really desirable in the air conditioning of buildings as given in Chapter 23 of the "Guide."[1]

The reasons for eliminating atmospheric conditions represented by the lower and upper portions of the comfort line never have had an accepted scientific basis and some of the reasons advanced for the undesirability of such conditions have been conflicting. The extreme dessication or drying out of body tissues, particularly in the exterior portion of the respiratory tract as mentioned by Major Corbett, is perhaps the best accepted reason for eliminating the atmospheric conditions in the lower region of the comfort line. Again the dusty condition of the atmosphere which is encouraged by the low humidity and high temperature is undesirable and probably harmful. The tendency for furniture to deteriorate and fall apart in high temperatures and low humidities is another reason for eliminating such conditions in our homes and offices although it may have nothing to do with health. The reasons for objection to air conditions in the upper region of the comfort zone also are not well founded but they will not be discussed here.

Major Corbett suggests that high dry bulb temperatures should be accompanied by higher moisture content and that the relative humidity should not fall below 20 per cent. While he gives no specific figures, we might assume that as the dry bulb temperatures rise above 70 the moisture content should be increased so as to give conditions on or above the line *AB* on the chart, Fig. 1. Such conditions would according to our laboratory study give considerable discomfort and it is doubtful if they would be more conducive to health, although admittedly we have no concrete data on which to base our belief.

A condition *x* on the line *AB* would not only be uncomfortably warm but it would be accompanied by a clammy condition due to accumulated perspiration on the body and forehead. If it were necessary to maintain a higher dry bulb temperature, it would appear that rather than encourage such a condition it would be desirable to move downward along the comfort line so as to at least eliminate the clammy condition of the skin—for after all, it is doubtful if mere loss of moisture from the system is harmful. It is more likely that the only harm results from too dry a condition of the skin and within reasonable limits the body automatically avoids this condition.—F. C. Houghten.

[1] GUIDE, American Soc. Heat. & Vent. Engrs., Chap. 23, 1929, page 377.

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

JANUARY 1930

Material in this Section prepared by Publication Committee: A. C. Willard, *Chairman*; N. W. Downes, and W. A. Rowe. : A. V. Hutchinson, Manager of Publications

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Panel Warming

By L. J. Fowler, London, England
NON-MEMBER

THROUGHOUT travels in over a dozen countries, the author has found that there prevails a popular belief that the Englishman spends his winter evenings in front of a large open fire in a room with fully opened windows. Such a state of affairs, whilst being a libelous exaggeration of the actual conditions in a typical English home, presages an elementary but instinctive conception of the fundamental physiological principles making for the comfort of the human body. In surroundings at 64 F., Rubner states that the mean surface temperature of clothes and exposed skin is about 75 F. Without artificial warming, at a temperature of 60-65 F., no sensation of cold is felt, but at a lower temperature than this, radiation and convection are increased and a feeling of chilliness occurs. If, however, the walls and ceiling of a room are maintained at about 75 F., the mean radiation losses from the human body are almost nullified; and although the air temperature may be as low as 50 deg., bodily heat, lost only by convection, is easily balanced by the normal metabolism so that no discomfort is felt. These conditions pertain only to still air, for in draughts convection increases, and rises in temperature of 3 deg. and 6 deg. are necessary to counteract air movements of 160 and 200 f.p.m respectively.

To give substantiation to the foregoing statements, it should be remembered that it is possible, although lightly clad, to feel comfortable in a snow-field, with an air temperature below freezing, provided that the sun is shining and there is no wind. The heat rays from the sun not only strike the body direct, but are reflected to it from the snow, thus counteracting the direct bodily radiation losses. If, however, the sun is obscured, or direct conduction and convection are increased by air movement, very different sensations are felt.

Reverting to our hypothetical room, as wall temperatures increase, air temperatures can be still lower. If, then, it were possible to reach commercially the ideal of raising the temperature of the whole of the walls to some temperature above 75 F. not only would comfort conditions result, but lower air temperatures could be maintained, giving a feeling of freshness, and with it the mental and bodily efficiency and good health of the occupants, who would not suffer from the lassitude inseparable from elevated air temperatures. Furthermore, the cost of fuel for the heating system would be reduced by lessening of the heat lost by changes of air, which, in tall buildings, is very considerable. In practice, however, even though the practical difficulties could be overcome, and the walls were evenly warmed to 75 deg., in a short time, although at an initial temperature of 50 deg. the air would be warmed 10 deg. or more by contact with the walls.

For presentation at the 36th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, January, 1930.

Radiant heaters, such as open fires and luminous electric heaters emit rays of varying intensities which, as well as directly impinging upon the occupants, strike the walls, ceiling, floor and furniture of a room. A portion of this incident energy is absorbed and raises the temperature of the object which it strikes, eventually setting up convection, and a part is reflected one or more times before it reaches any of the occupants. With these forms of heater, it is conceded that, not only is there excessive variation in comfort—and degree of discomfort—throughout the room, but the fuel or power consumption reaches an uneconomic figure. It should be noted at this point that high temperature heat rays have different coefficients of absorbtion and reflection from the longer waves which would be emitted from a low temperature source, such as the walls referred to above, maintained at 75 deg. As an example, as glass is transparent to light waves, it is largely diathermous to the shorter heat waves; whilst approximately 90 per cent of low temperature heat waves are directly reflected, the remaining 10 per cent partially pass through and partially are absorbed by the glass.

Whilst the higher temperature radiant source is far from satisfactory, the heating of the whole of the walls, ceiling, etc., is not commercially possible, and over 20 years ago Prof. A. H. Barker conceived the idea of the radiator—the word being used in the scientific and not the commercial sense—of comparatively large surface and comparatively low temperature. His patents were taken over and developed by the London firm Richard Crittall & Co., Ltd., to whose efforts is due the very effective compromise called "Panel" Warming, in which large surfaces are warmed to a relatively low temperature which, at times, need not far exceed the 75 deg. of the ideal room. On occasion, the walls are warmed, but this it not ideal, for not only is convection set up, but there is limitation to the positions in which heavy pieces of furniture may be placed without obstruction to the uniform distribution of heat. The modern practice is to install the warming surface—termed *panels*—in the ceilings, and this is not only the logical position from all theoretical considerations, but it engenders simplicity and ease of installation as well as other advantages which will be explained later.

The panels generally consist of coils of pipe through which water flows, and the inevitable development of the principle to electrical power has been eminently successful. The pipes, usually of ½ or ¾ in. diam. run parallel to each other at 4 to 6 in. centres and are embedded in concrete in the underside of the ceiling of the room to be heated. The surface of the concrete is then plastered, rendering the panel invisible. Heat is conducted from the pipes to the plaster face and is then emitted in radiant form. The surface temperature of the plaster is considerably lower than that of the water flowing through the pipes, and is affected by their diameter

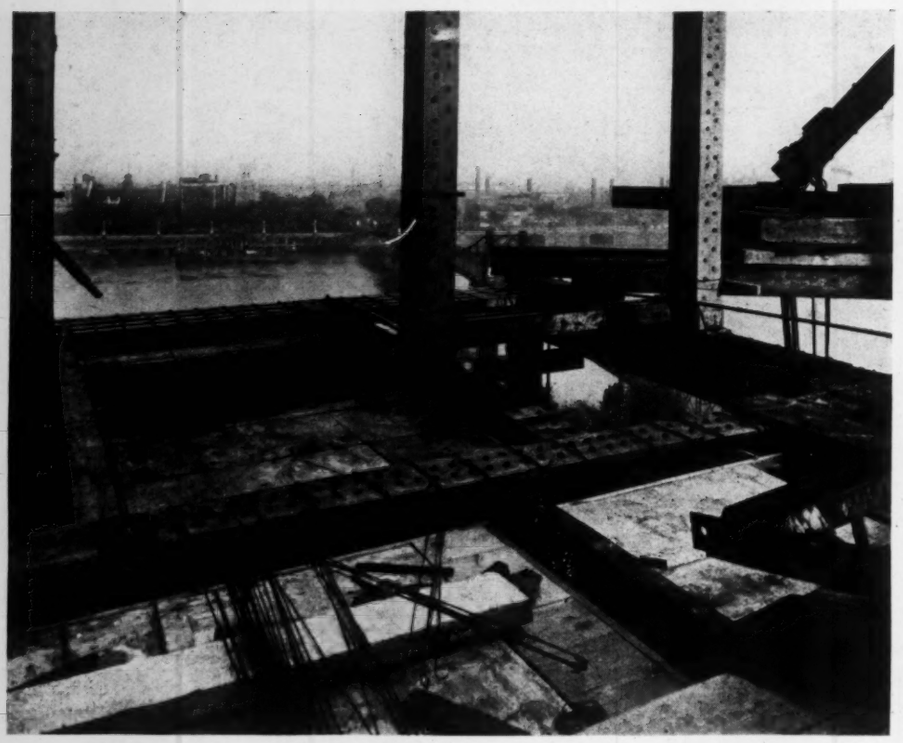

FIG. 1—WARMING PANEL ON SHUTTERING READY FOR CASTING

and spacing. At the centres given, it is found that over the whole of the panel, the temperature varies little.

Dr. Margaret Fishenden states that if pipes of external diameter $2a$, spaced at centres $2d$ apart, at an axial distance x in. below the surface of the plaster of which the conductivity is k, when t is the absolute temperature of the pipes and T_1 the absolute temperature of the plaster face, the quantity Q of heat transmitted is given by the equation:—

$$Q=\left[\frac{4k\ (r-T_1)}{\log_e \dfrac{a\ d}{2x\sqrt{x^2+a^2}}}\right]\tan^{-1}\frac{2d}{x}$$

If this plaster surface radiates heat to surroundings at a mean absolute temperature T_2, the heat emitted is given by:—

$Q=K\ (T^4_1-T^4_2)$ where K=emissivity.

Allen and Griffith and Davis have found that, with normal plastered and painted surfaces at low temperatures the emissivity is usually within 85-90 per cent of theoretical black body emissivity.

Practice shows, however, that the actual heat lost from warming panels is considerably in excess of that expected from the equations. There are several reasons for this in a good installation, the most important being air movement. With a ceiling panel fixed flush with the remainder of the surface of the ceiling, in still conditions convection is zero, but should the panel surface be lower than that of the surrounding ceiling, as sometimes occurs when an installation has been made in an existing building, or should the material of the ceiling be cracked or porous, a certain amount of convection occurs which slightly increases the total heat emission. If, however, a definite air current blows across the panel, very appreciable increases occur in the total heat emitted, with reduction of the proportion radiated.

Another factor arising to explain the discrepancy between the theoretical and the practical emissions is the heat conduction upwards from the panel. In a normal solid concrete floor construction, in which the concrete is 8 in. thick, the difference in the conductivity between approximately 7 in. concrete above and approximately 5/8 in. plaster below the panel is sufficient, however, to reduce the upward transmission to a small proportion of the heat lost from the panel. A further reduction is at times effected by interposition above the panel of layers of one of the insulating compounds on the market. A hollow tile floor construction permits less upward loss of heat than a solid concrete, and if the panels are installed in a suspended ceiling, cork or silicate of cotton prove an effective means of retarding the upward flow, and at the same time reduce the deleterious effects of air currents.

In 1909 the first panel warming system was developed, in which the heat was distributed and evenly radiated through a building from within the ceilings, walls and floors. To form radiators which would diffuse heat invisibly, the coils of pipes were embedded in the walls and floors, and although many difficulties had to be overcome, the system was an immediate success. The Royal Liver Building in Liverpool, which has over 1,000 rooms, was the first large building to be equipped in this way, and the system attracted so much attention that a second installation was made in the Midland Adelphi Hotel which was soon erected in the same town. The healthy and pleasant conditions in these two buildings favourably attracted the attention of the medical profession, and panel warming installations were adopted for hospital work.

The War caused a temporary setback, but the boom in building which subsequently began stimulated development of the system, and now it is widely adopted in the best class construction work in England, which, during the past year, includes both the new Bank of England, the Northern Ireland Parliament Buildings, and the London Offices for the Imperial Chemical Industries—the classic of modern British commercial buildings.

The panel system, as generally applied, is a low pressure hot water system, the circulation being either accelerated or by gravity in smaller installations. The distributing mains are designed in a similar fashion to those of a radiator system, but are connected to the panels instead of radiators.

The panels, in the form of continuous coils, are generally fixed in the ceilings, and are of special quality

steel pipe. When a reinforced concrete floor is used, the coils are laid on the shuttering, or forms, and connected to the mains which are usually run adjacent to the stanchions. Before delivery to the site, a works test is made at 500-lbs. per square inch with compressed air under water, but when the coils are connected to the mains, a hydraulic test of 250 lbs. is applied for several hours before the concrete is cast.

If the floor is constructed by a method which does not employ forms, the coils can be fixed from below, a similar procedure being applied when the system is applied to existing buildings or to false ceilings.

The coils themselves are bent and welded electrically at the works, but all joints during erection are made by the oxy-acetylene welding process.

The heating system of the Royal Liver Building, referred to above, has 55,000 oxy-acetylene welded joints and has stood the test of twenty years.

The heating contracts which were carried out simultaneously by one firm in London three years ago include 75 miles of pipe necessitating 15,850 electric and 13,000 oxy-acetylene welds, all of which have been buried in concrete.

Work on a panel installation commences earlier than that on a similar radiator installation, and close co-operation between the main heating and floor contractors is essential. The fitters follow closely behind the shuttering gang, laying the panels and fitting the necessary connections to the mains as soon as a bay is shuttered. The welders who follow, join up the connections and then come the testers who mark each bay as it is passed, ready for the concrete of the floor to be poured.

It will be seen that by these means, providing an effort is made to complete the boiler-house work and to run the mains, the panel warming system can be set in operation very early, sometimes even before the walls are constructed.

The value of a heating system at so early a stage is immensurate, for not only are working conditions improved for the operatives of other trades, but drying out of concrete and plaster ready for the reception of joinery etc. allows the progress of the whole construction to be advanced at an abnormal rate. In some cases, it is even profitable to install temporary boilers and mains to obtain this early heat.

In most reinforced concrete or hollow tile constructions, the coils are cast in concrete in the soffit of the floor over that which has to be heated. The temperature of the water gravitating or pumped through the system is not sufficiently high to set up expansion stresses which cannot be taken up by concrete without movement or cracking.

When the concrete is sufficiently matured, the ceilings are hacked if no satisfactory constructional key has been provided, and plaster is applied according to a specification set out by the patentees of the system, as a precautionary measure against cracking which takes place if the materials or workmanship are of inferior quality. If reasonable care is taken, the failure of plaster work in contact with panel surfaces maintained at the normal working temperature need not be feared, and reputable plastering firms in England will give a five-year guarantee for work of this type.

Application of panel warming is not confined to concrete construction. In Devonshire House, an apartment building erected in London some three years ago to the design of Messrs. Carrere & Hastings of New York City, in conjunction with Prof. Reilly of Liverpool, the panels heating the three top floors were incorporated in Hy-rib suspended from the constructional floors. In cases such as this, the coils are fixed over and wired to the Hy-rib; plaster is then applied, care being taken to force this through the mesh to obtain an intimate contact with the pipes to allow free conduction of heat from the latter to the plaster face. In order to reduce convection currents and radiation to above, silicate of cotton is carefully laid above the panels to a depth of about 6 in.

Standard arrangements have been developed for incorporation of coils behind marble walls, floors or ceilings behind terrazzo walls and floors, below wood joist floors and finally to existing ceilings, by means of special pre-cast plaster slabs which contain the coils, and which are finished in comformity with the decorations of the rooms in which they are fixed.

Other types of panel can be applied to surfaces of walls and ceilings of new or existing buildings. The pipes are attached to either cast iron or steel plates; in the former case the pipes are cast with the plates in standard sizes, which are connected together with right and left hand nipples. In these Ray-rads as they are called, the heat from the pipes is conducted through the plate, the variation in temperature over the whole plate being between 10-deg. and 20 F. Excellent results are obtained, and the surface of the plates can be treated in numerous ways to match decorations. The standard sizes of the castings, however, frequently present difficulties in application. For surface application coils similar to those normally cast in concrete are sometimes attached by rivetted bands or by spot welding to rolled sheet steel plates, to give as intimate a thermal contact as possible. These panels can, of course, be made of any size and present less difficulty in connecting up than Ray-rads. Both the Ray-rad and sheet steel panels can be used with steam, hot water, or water heated under pressure to above the normal boiling point, and thus offer a wide field of application in commercial buildings, factories, etc.

The consumption of electrical power in England has doubled since 1922, and upon the completion of the Government development scheme in which the power stations are centralized into 150 inter-linked units, an even greater stimulus will be given to an application of Panel Warming which is finding favour in an ever increasing field.

Electric panels of the Dulrae type are formed of a light asbestos sheet faced with cork, on which is placed a layer of plaster composition about ¼ in. thick, containing a grid work of specially insulated wire element, making a panel of a total thickness of about 1½ in. The panels are made in stock sizes, 36x12 in. and 72x24 in. and for various voltages up to 250; they can be operated by either direct or alternating supplies. In existing structures, a number of standard units, connected to form a complete panel of suitable dimensions, are finished with a neat beading, and screwed to the surface of ceilings or walls. In a new structure or one where cutting away does not involve serious difficulties,

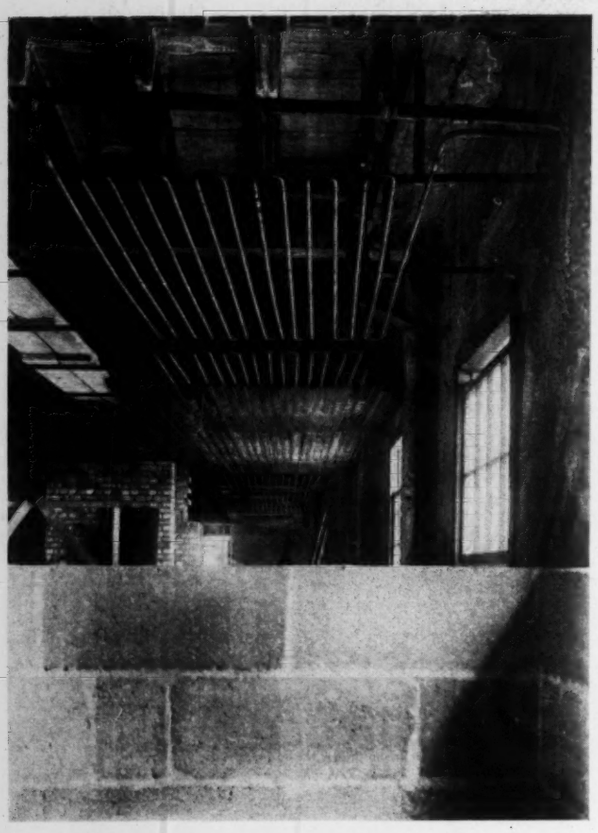

FIG. 2—WARMING PANELS APPLIED TO A HY-RIB CONSTRUCTION

the panels can be sunk flush with the finished ceiling or wall face. At times, the elements are fixed behind mirrors, in portable folding screens and, if special precautions are taken for waterproofing, in floors of bathrooms. The power absorption is calculated to give a surface temperature of about 120 deg. to 130 F. on continuous running, but when thermostatically controlled, the mean temperature is in the neighborhood of 80 to 90 F.

Dulrae panels are either switched on independently or arranged for series parallel control in the ordinary way, giving 100 per cent, 50 per cent or 25 per cent of the maximum heat available.

The most efficient method of control is by means of a thermostat operating direct or alternatively through a contactor switch when the load is great.

A compromise between the hot water and the Dulrae Panel is gaining popularity; heating elements are encased in sheaths of glass which are placed inside steel tubes, the space between the two being filled in with a plaster material to permit ready conduction from one to another. The tubes are cast into ceilings or walls, or at times into floors; the positions that they occupy and the results obtained from them are similar to those of hot water panels.

Another form of electric panel, called the Morganite Panel, has useful spheres of application, but although not luminous, the working temperature is higher and the human body is sensitive to the heat rays emitted.

Electric heating especially lends itself to measurement of power and from installations of this type much has been learnt of the fuel consumption of panel systems.

By the courtesy of J. L. Musgrave and R. G. Crittall, to whose foresight and ingenuity, and above all, to whose fortitude, the development of the panel warming is mainly due, I am enabled to give below some figures obtained on an electric panel installation in London during the severe winter of last year. The heating season was prolonged from October 1 to May 1, a period of 212 days, with an average recorded temperature of 43 F. The building under test contained eight large rooms, hall, staircase, etc., and by thermostatic control was maintained at 60 F. at which temperature the radiant heat secured conditions of comfort. The total connected load of the electric panels was 20 Kw, making 101,760 Kw-hr available throughout the 212 days. The actual power consumed was 30,300 units, approximately one third full load. The cube of the rooms warmed was 21,250 cu. ft., making a total of 1.42 units per foot cube—a moderate annual charge.

A northerly room of 3,250 ft. cube and equipped with 65 sq. ft. of heating surface gave an average daily consumption of 10 units for 24 hours, costing approximately one third as much as a gas fire in an adjoining building.

Experience proved that panel warmed buildings are run with the minimum fuel consumption when they are maintained at a steady heat temperature throughout the winter. Serious losses of fuel or electric power result from rapid heating after prolonged cooling, but if ample radiating surface is installed, the maintenance of a steady and moderate temperature, besides being most economic, gives the greatest comfort to the occupants.

In England, it is found that under these circumstances the hourly consumption is about one third of that of an intermittent service—a readily computable saving for a building in occupation for twelve hours a day.

Owing to the almost complete absence of convection, hot strata of air are not formed in the upper portions of rooms warmed by ceiling panels, and there is thus a palpable fuel economy, for less heat is lost from convection and over-warmed air escaping through the upper portions of windows.

The prime cost of a low pressure hot water panel installation exceeds by only a small margin that of a similar radiator system if the expense of enclosing and decorating the exposed portions of the radiator system is considered. Furthermore, the value to other trades of the early provision of heat to the unfinished building cannot be readily estimated, but there is no doubt that in modern construction, in which speed is a paramount consideration, it definitely justifies increased expenditure on the heating system.

Architecturally, the system is supreme. The complete invisibility of the radiating surface and of the risers is only relieved by the control valves, fixed in suitable positions within metal access boxes, and by means of which the panels can be controlled from the rooms which they warm. No space is wasted and no unsightly marks of dust arising from convection despoil the decorations of the walls and ceilings. It is frequently desirable in modern commercial buildings, especially those which are sublet as offices, to modify the positions of partitions, a condition to which panel warming is readily adaptable, for the heating surface is uniformly distributed and each bay with its requisite heat-

ing surface and control valve or valves is an independent unit.

The architectural virtue of invisibility is claimed by some to engender a vicious element. Unless the greatest care is taken in the preparation of accurately detailed record plans, difficulty may subsequently be experienced in locating the exact positions of the pipes, and alterations to the system are therefore difficult. These, however, are rarely necessary, for the reason given above. In a well designed installation, sub-division by partitions is relatively unimportant.

There are two matters to which reference should be made at this point, namely, expansion and corrosion. The coefficients of expansion of concrete and mild steel are 0.62×10^{-5} and 0.66×10^{-5} per degree Fahrenheit respectively, and the stresses set up in the concrete owing to the higher expansion coefficient of the steel, at the normal working temperature of 120 deg. are not sufficient in magnitude to cause failure or cracking.

Internal corrosion is not serious in a system where the make-up water is not great. Oxygen is slowly admitted through valves and the pumps in an accelerated circulation, but experience does not show that the quantities are sufficient to be dangerous. The causes of external corrosion have to be studied by the steelwork and reinforced concrete contractors as well as the heating engineers, and no trouble is experienced if the materials in which the pipes are encased are selected with care. It is important, however, to avoid any oxy-chloride compounds.

Reference has already been made to the economy of maintaining a steady supply of heat. A panel warmed building shows remarkably steady temperatures, in spite of severe external conditions. The building fabric which is warmed throughout, has a large heat capacity; the reaction, therefore, to any sudden drop in temperature is slow, and if control is effected by external thermostats, increase of flow temperature compensates the additional heat loss without affecting the comfort of the occupants.

On behalf of the Industrial Fatigue Research Board, Dr. Vernon has carried out a series of tests in Panel warmed rooms during the last three years. As well as with thermometer readings, observations were made with Moll's Thermopile and the Kata thermometer. Remarkable evenness of conditions existed throughout a room warmed with a ceiling panel fixed near to the window for there was no more than 1 deg. of difference of temperature between the floor and the ceiling. Estimation of wall temperatures obtained with the thermopile indicated that the mean wall temperature was from 2 deg. to 3 deg. higher than that of the air. Subjective observations made during the same series of tests showed that a temperature of comfort was only obtained in a panel warmed room at 1 deg. lower than in a room heated by convection.

Actual experiments upon the heat losses from people

FIG. 3—WARMING PANELS APPLIED TO A BARREL CEILING

and the practical experience of the installers of the system indicate that Dr. Vernon's figure for the permissible lowering of air temperature is underestimated.

In the last few years, remarkably even temperatures have been maintained in panel warmed buildings in which the boilers have only been fired for about one-third of the day.

During this period, the excess heat generated is circulated to large storage tanks, where the temperature of the water rises as high as 280 F. under the head of the building. An automatic mixing valve, controlled by a thermostat fixed in the flow pipe, permits the water circulating through the system to be continuously maintained at the required temperature, generally between 90 and 120 F. by mixing with it a proportion of water from the storage tanks, which gradually fall in temperature until the boilers are once more operated. In some installations, the storage tanks themselves are directly heated by thermostatically controlled immersion heaters which are operated on the night load by means of time switches.

Satisfactory results are also resulting from the thermostatic control of individual rooms by solenoid operated valves controlling the flow of water through the panels. From economic reasons, a low pressure, generally either 8 or 25 volts, is chosen for the electrical supply to the valves. In small installations, batteries are generally used, being fed from trickle chargers, but in larger installations, rotary converters are more satisfactory. The thermostatic element is a bimetallic strip, which makes the circuit and thus closes the valve when the room is warmed to the temperature indicated on the indicator dial of the thermostat, which is set by hand. The circuit is broken when the temperature falls 1 to 1½ degrees F. and the valve opens. Where one thermostat controls more than four valves, it is usual to employ a relay, since the lag between the opening and closing temperatures is otherwise increased. Continuous recording thermometers placed in the rooms controlled in this way show variations of internal temperature of less than 2 degrees throughout twenty-four hours, although the external conditions have changed abnormally. A sufficient testimonial to the efficacy of the thermostatically controlled solenoid valve in conjunction with Panel Warming is the contemporary installation of this dual system in a commercial building in London containing approximately 1,700 rooms.

A further development of fundamental importance is the use of panel systems for cooling during summer months. Cooling water at a temperature of between 40 and 50 F. is circulated through the pipes and only a very slight lowering of room temperature is required. The cooled panel surface absorbs the heat radiated from occupants, walls, floors, etc., and there is a definite absorption from convective currents which at the same time prevent condensation at the working temperatures found desirable.

It would be invidious for me to describe the panel system to you as the panacea for all troubles of the heating engineer. Mention has already been made regarding the inaccessibility of the installed system, and careful planning and erection are inseparable requirements of its successful application. Present practice is the result of 20 years of continuous experiment, during which many difficulties have been successfully overcome. In every installation, careful supervision is necessary to ensure that the coils are levelled to prevent air locks and hydraulically tested before they are connected or otherwise made inaccessible. Furthermore, external corrosion must be considered in the selection of materials in which the pipes are encased. In the Bank of England, which is now being rebuilt, every effort is being made to ensure longevity, and it is an interesting fact that a panel system of copper pipes has been chosen.

Supervision of the plastering is desirable to ensure that the correct mixtures are used and the work is well executed. It is the general practice to work a scrim into the finished face of the plaster surface to the panels, and it is essential that care is taken that slovenly workmen do not apply a thin plaster coat after the scrim, as the continuity of the setting coat is then broken, resulting in a tendency towards the formation of cracks. Furthermore, if the heat has already been in operation, it must be shut off several days before plastering and not turned on again until at least four days after the application of the setting coat, the valves being cracked slightly and gradually opened day by day. On large contracts, it is usual to detail a man to keep in close touch with the plaster work, to see that the panels are turned off when necessary and only opened slowly. At the same time, it is his duty to take a note of the materials and application of the plaster itself.

The boom in building and the rapidly enhanced popularity of panel warming after the war at first caused an insufficiency of oxy-acetylene welders. To meet the growing demand, instruction in this comparatively new trade was undertaken both by the larger contractors and at schools, and now there is constant work for the trained man.

Standardization of coils and connections from coils to risers is an essential factor of low costs.

Since the cost of electric welding and bending at the factory is only a small fraction of that of oxy-acetylene welding and bending on the site, the pipes are there cut to length and bent by suitable dies, and little is necessary on the building itself beyond the welding up in position.

Intensive organization and co-ordination with other trades bring about ease and rapidity of installation which amply repay the consequent increase of supervision charges. The installation is made continuous and is practically completed before the building construction reaches the difficult final stages. It is then only necessary to maintain a small staff to carry out the testing and regulation and to attend to the running of the plant before the permanent staff takes charge.

Early completion is a factor beneficial not only to the contractor, but to the general progress of the construction as a whole and is fully appreciated by architects.

No mention had yet been made of the development of panel warming outside the land of its origination. European extension is progressing rapidly. The licensors have granted agencies in Holland, France, and negotiations are in hand with firms in Germany and Czecho-

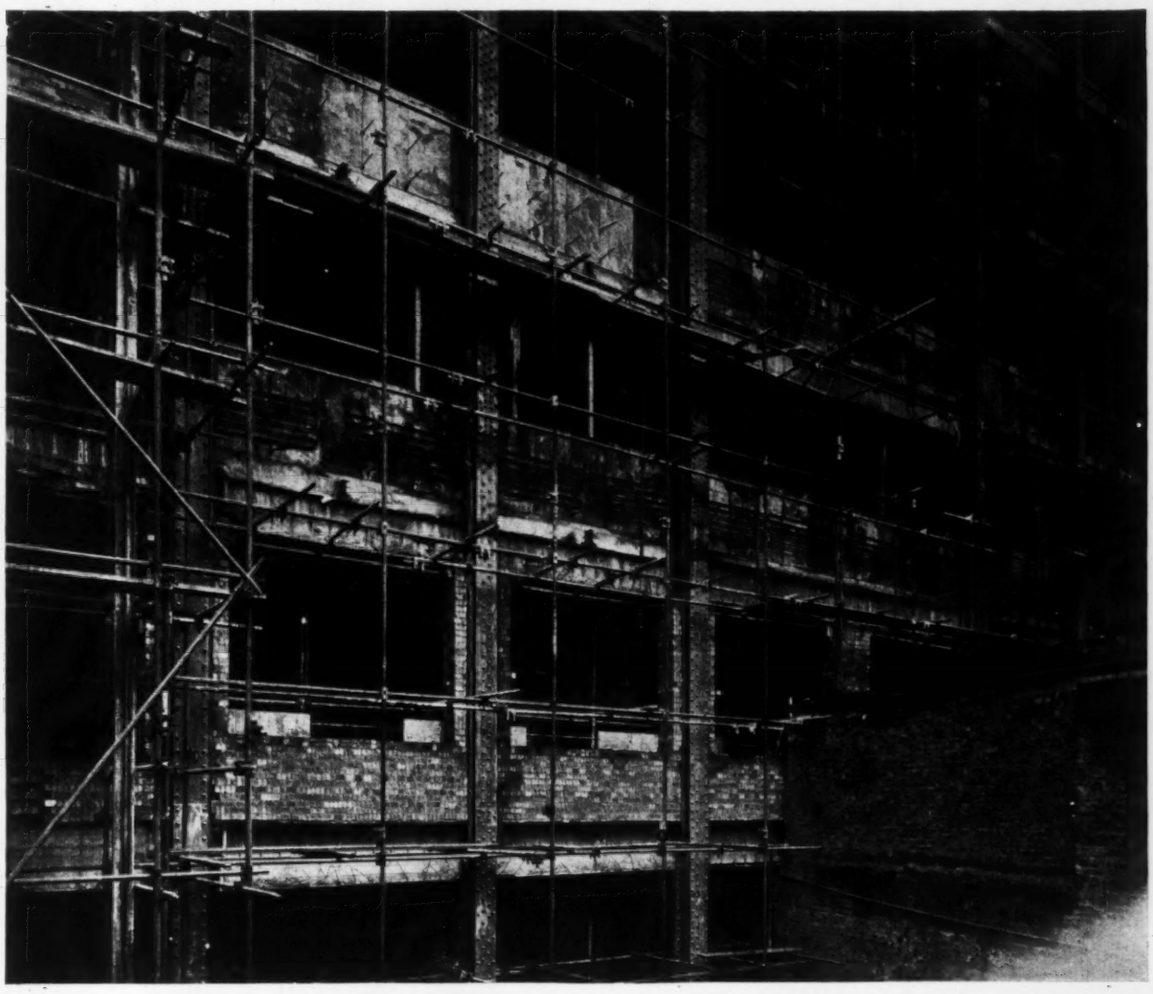

FIG. 4—WARMING PANELS READY FOR CASTING INTO WALLS

Slovakia, and Imperial extensions are rapidly increasing. Large contracts have been carried out in New Delhi and elsewhere in India, and contracts are in hand in China and Australia. In this country, as you know, the British embassy at Washington has just been completed under the auspices of the most famous of modern British architects.

In conclusion, the panel system is a step towards the ideal; at the moment, a somewhat laborious attempt, but a well-founded attempt to apply the methods of nature to the needs of civilized mankind, and twenty years of experience have each brought their improvements which made the difficulties of the previous years worth overcoming.

One instinctively points to the extension of developments in the electrical application of panel warming, but it is impossible to see far, and progress can only be developed step by step.

The principles are those used by the Romans 2,000 years ago with their underground flues, and although methods have changed, it can be forecast with no lack of confidence that future developments will lead to the provision of uniform distribution of radiant heat energy in the successful warming of buildings.

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Rating of Heating Boilers by Their Physical Characteristics

By C. E. Bronson,[1] Kewanee, Ill.
MEMBER

THIS paper is presented in explanation of the Code for the Rating of Low Pressure Heating Boilers adopted by the members of the *Steel Heating Boiler Institute*. The complete text of the Code has been submitted to the Society's Committee on Rating Low Pressure Steam Heating Boilers and will be found at the end of this paper.

This method of rating boilers is offered as an alternate to the method of determining ratings by means of test characteristics. The proposed method has the advantage of representing the size of the boiler by a single number, which has a certain and definite relation not only to the load for which the boiler is selected, but also to the operating characteristics of the boiler itself. This single number rating is easily determined from measurable proportions of the boiler and obviates the necessity for a long and expensive program of tests.

There has been much discussion on the question of boiler ratings and the relation of rating to selection. Attempts have been made to separate consideration of the two but the author believes they should be inseparable. The rating should be a single number and should have a definite relation to the load imposed on the boiler. This method has been successfully used by the manufacturers of steel heating boilers for many years. The rating of a boiler by any other method than the one proposed would cause confusion to those accustomed by long years of practice to selecting boilers from a single number rating.

If a single number rating is assigned to a boiler it must be an indication of capacity. The capacity of a boiler is dependent upon two main variables.

1. Rate of fuel burning.
2. Ability to absorb heat.

The rate at which fuel may be burned is dependent upon the area of the grate, the kind of fuel and the available draft. If the draft required or the chimney size is given for the ordinary grades of fuel used, it would be possible to assign a value for the rated capacity of a boiler based on the grate area. This considers only hand-fired solid fuel burning boilers.

The ability to absorb heat is dependent upon the amount of heating surface interposed between the grate and the chimney. Therefore, it is logical to assign a uniform value of capacity based on total heating surface. Then it is possible to assign a capacity value or rating to a heating boiler based on:

1. Heating surface.
2. Grate area.

The proposed Code defines the rating as the heating surface multiplied by a factor of 14. There is a precedent in the choice of such a factor. Ratings for power boilers have been made for years on the basis of 10 sq. ft. of heating surface per boiler horsepower. A boiler horse-power is defined as the evaporation of 34.5 lb. of water per hour, from and at 212 F. This is equal to the delivery of 34.5 × 971.7 (latent heat at 212 F.) or 33,524 B.t.u. per hour. Expressed in square feet of radiation, a boiler horsepower is equal to $\frac{33{,}524}{240}$ or 139.7, practically 140.

With 10 sq. ft. of heating surface per boiler horse-

TABLE 1. MINIMUM HEATING SURFACE AND GRATE AREA REQUIREMENTS WITH CORRESPONDING FIRING CHARACTERISTICS WHEN BOILER OUTPUT IS EQUAL TO RATING.

Boiler Rating — Sq. Ft. Steam Radiation	Heating Surface — Sq. Ft.	Grate Area — Sq. Ft.	Combustion Rate[a] — Lbs. Coal per Sq. Ft. Grate Area per Hour	Fuel Charge[b] — Lb.	Firing Period — Hours
300	21.4	1.98	4.66	78	8.5
400	28.6	2.80	4.39	111	9.0
500	35.7	3.42	4.49	135	8.8
750	53.6	4.64	4.97	184	8.0
1,000	71.4	5.60	5.49	222	7.2
1,500	107	7.14	6.47	283	6.1
2,000	143	8.39	7.34	332	5.4
2,500	178	9.5	8.1	376	4.9
3,000	214	10.5	8.8	415	4.5
4,000	286	12.2	10.1	483	3.9
5,000	357	14.4	10.7	570	3.7
6,000	429	16.4	11.2	650	3.5
7,000	500	18.1	11.9	716	3.3
8,000	571	19.7	12.5	780	3.2
9,000	642	21.1	13.1	835	3.0
10,000	714	22.5	13.7	890	2.9
12,000	857	25.0	14.8	990	2.7
14,000	1,000	27.3	15.8	1,080	2.5
16,000	1,143	29.4	16.7	1,164	2.4
18,000	1,285	31.4	17.6	1,243	2.2
20,000	1,430	33.2	18.5	1,314	2.1
22,500	1,608	35.3	19.6	1,397	2.0
25,000	1,780	37.4	20.6	1,480	1.9
27,500	1,963	39.3	21.5	1,555	1.8
30,000	2,140	41.1	22.4	1,626	1.8
32,500	2,320	42.9	23.3	1,700	1.7
35,000	2,500	44.5	24.2	1,760	1.6

a Combustion rate calculated for 65 per cent efficiency and 12,000 B.t.u. coal. Fuel charge based on 10 in. depth of coal weighing 47.5 lb. per cu. ft.

b These figures do not allow for the rehandling charge which is usually figured as 25 per cent of the fuel charge.

[1] Mechanical Engineer, Kewanee Boiler Corporation.

For presentation at the 36th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1930.

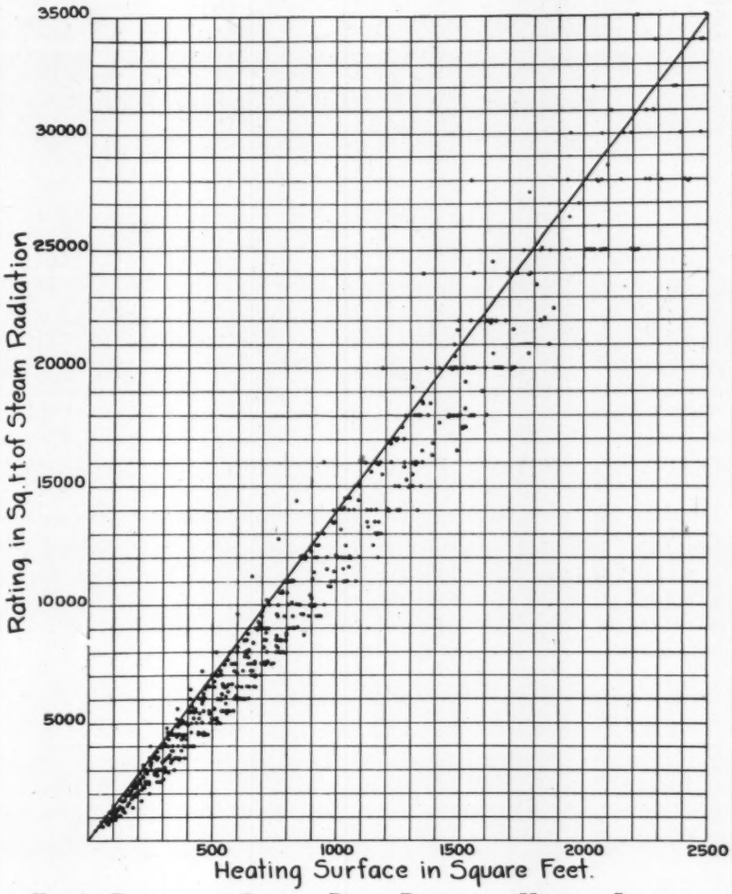

FIG. 1. RELATION OF PRESENT BOILER RATINGS TO HEATING SURFACE

power of rating, the ratio of rating surface becomes 14, the figure selected.

The practice in former years in selecting boilers based on boiler horse-power was to allow one boiler horse-power for every 100 sq. ft. of radiation leaving a margin of 40 per cent to take care of losses in mains, risers and returns. This is equivalent to making the boiler rating 10 times the heating surface. Since 40 per cent is rarely required to care for losses due to mains, etc., present boiler ratings have been assigned on ratios varying from 10 to 12 times the heating surface, the manufacturer recommending that losses due to mains, risers and returns need not be figured but that the boiler be selected on the basis of installed radiation. Other manufacturers have assigned still higher ratings based on values as high as 14 times the heating surface and recommending that the entire normal load be used in selecting the proper size of boiler. A uniform method is desirable, consequently the proposed Code recommends in placing the rating at 14 times the heating surface, that the total normal load be used in selection. By this method the boiler rating is equal to the boiler output required for the normal heat demand.

Fig. 1 shows how present boiler ratings are based on heating surface. Although more than 800 boiler sizes are plotted, there are not this number of points indicated as some of the values are coincident. The curve shown gives values of ratings equal to 14 times the heating surface. Similarly, Fig. 2 indicates the relation between grate area and rating for the same boilers. The curves shown are plotted from the formulae given in the Code.

In order to give a clear conception of the Code requirements, Table 1 shows the minimum heating surface and grate areas for boilers of various ratings. For each rating, values of combustion rate, fuel charge and firing period are given for the condition when the boiler output is equal to the rating.

The formulae for minimum grate area were developed after due consideration had been given to the various factors involved. In general, small boilers installed in residences are connected to chimneys of 30 or 40 ft. in height. The draft available from such chimneys is comparatively small in value. Long periods of time without attention to the fire are desirable. In hand-fired boilers the grate must be utilized partly as fuel storage space. Consequently, rates of combustion for small boilers must be kept low in value. Larger boilers have higher chimneys, are fired more frequently and therefore may be allowed higher combustion rates.

While more grate area should be allowed for small boilers than for large boilers, it seemed that the rating of boilers of acceptable proportions increased approximately according to the square of the grate area. This can be readily noted by reference to Fig. 2. The formulae cover two ranges of rating values as it was considered easier to use even instead of fractional exponents. Resulting grate areas calculated by the formulae were also checked with the allowances made by other authorities[2] and found to agree quite closely.

There is no priming limitation mentioned in this Code. It has always been tacitly understood that a boiler built for producing steam means one capable of furnishing steam only and not a mixture of steam and water. A limitation of moisture content of 2 or 3 per cent would be acceptable and reasonable. Since a boiler which would furnish more than a reasonable amount of moisture with the steam could be no longer classed as a steam boiler, it is believed unnecessary to comment further on this point.

Rating, according to this Code, is made equal to the estimated design load or normal load and is the recommended basis of selection. The three items considered as making up the estimated design load are the same as items *A*, *B* and *C* outlined in Section V of the A. S. H. V. E. Code of Minimum Requirements for the Heating and Ventilation of Buildings. No reference has been made to starting load or the load imposed on the boiler due to warming up cold mains and radiation. The starting load is considered an overload on the boiler above its rating and is taken care of by the boiler manufacturer in the specification of chimney for each boiler. Under present methods of selecting steel boilers and with chim-

[2] *Net loads for Heating Boilers* issued by the Heating and Piping Contractors National Association in April, 1929.

neys as recommended, the maximum output exceeds the total requirements as specified in the Code of Minimum Requirements. In other words, there is greater margin allowed between maximum capacity developed and normal load. Maximum capacity is dependent primarily on available draft and efficiency of the heating surface.

The constants used in the Code for the determination of rating are admittedly arbitrary. Yet these constants have been selected with due regard to controlling factors. Furthermore, the boiler manufacturers themselves have expressed willingness to be governed by these values with the idea of securing uniformity in the method of rating. The individuality of any boiler manufacturer is not submerged since the question of capacity only is covered and the question of efficiency is left open.

No attempt has been made to evaluate heating surface. Otherwise this Code might have the aspect of a construction Code rather than a sizing Code. Nevertheless, the requirement of a total heating surface of a certain value will insure a certain minimum efficiency. Efficiencies of a higher degree will be governed entirely by the ingenuity of the manufacturer in providing not only for high furnace efficiency by means of insuring thorough mixing and burning of the gases before they leave the furnace, but also by providing sufficient water volume for the heating surface, thereby preventing steam blocking, with consequent rapid decrease in heat transmission as the rate of heat transfer increases.

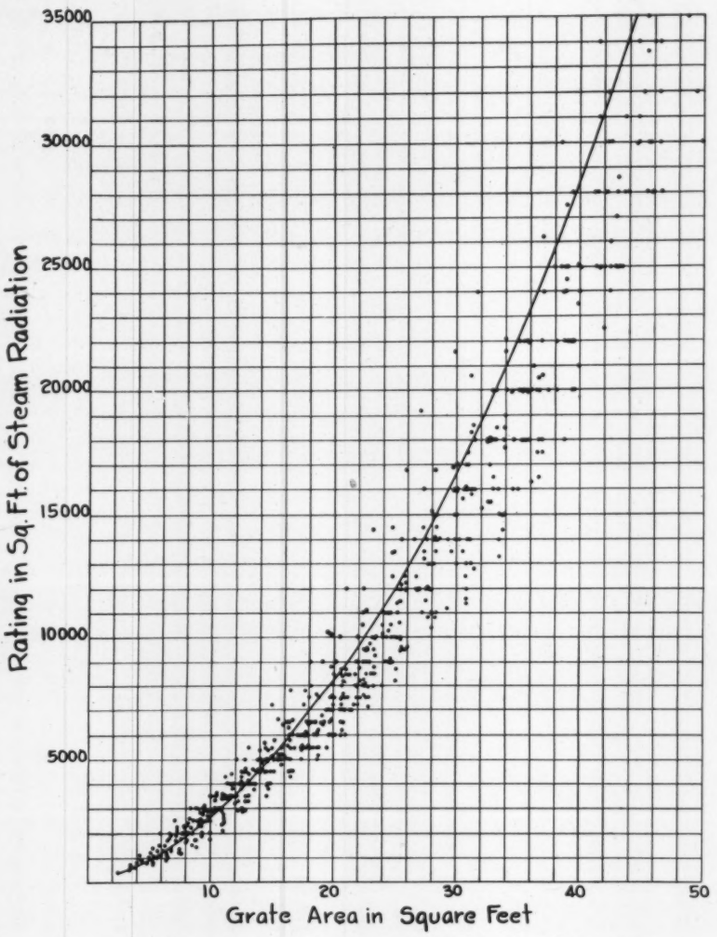

FIG. 2. RELATION OF PRESENT BOILER RATINGS TO GRATE AREA

Code for the Rating of Low Pressure Heating Boilers

Adopted by the Steel Heating Boiler Institute December 10, 1929.

1. The purpose of this Code is to provide a uniform method of rating Low Pressure Heating Boilers.
2. The rating of a boiler shall be expressed as square feet of steam or water radiation or as B.t.u. per hour.
3. For purposes of this Code, boilers are divided into two general classes as follows:
   A. Steam and Water Boilers in which solid fuel, hand fired, is used as the heat generating medium.
   B. Steam and Water Boilers in which solid fuel, mechanically fired, oil or gas is used as the heat generating medium.
4. The rating of a boiler in Class *A*, expressed in square feet of steam radiation, shall be not more than fourteen times the heating surface of that boiler in square feet.
5. The grate area of a boiler for the rating as determined by Section 4 shall be not less than that determined by the following formulae:

   For boilers with ratings 300 sq. ft. to 4000 sq. ft. of steam radiation;

$$\text{Grate area} = \sqrt{\frac{\text{Catalogue Rating (in sq. ft. Steam Radiation)} - 200}{25.5}}$$

   For boilers with ratings of 4000 sq. ft. of steam radiation and larger;

$$\text{Grate area} = \sqrt{\frac{\text{Catalogue Rating (in sq. ft. Steam Radiation)} - 1500}{16.8}}$$

6. The rating of a boiler in Class *B*, expressed in square feet of steam radiation, shall be not more than seventeen times the heating surface of that boiler in square feet.
7. The furnace volume of a boiler (as defined in Section 10) for the rating (as determined by Section 6) shall be not less than one cubic foot for every one hundred and forty square feet of steam rating.
8. Boilers selected on the basis of this Code shall be connected to stack and breeching in accordance with the manufacturer's specifications.
9. The rating as defined above for purposes of selection is intended to correspond to the estimated design load, which is to be the sum of items A, B and C.
   A. The estimated normal heat emission of the connected radiation required to heat the building as determined by accepted practice expressed in square feet of radiation or in B.t.u. per hour.
   B. The estimated maximum heat required by water heaters or other apparatus connected to the boiler, expressed in square feet of radiation or in B.t.u. per hour.
   C. The estimated heat emission of piping connecting radiation and other apparatus to the boiler expressed in square feet of radiation or in B.t.u. per hour.
10. Definitions:

    For purposes of this Code the following definitions will be used:

    A. One square foot of steam radiation shall be considered equal to the emission of 240 B.t.u. per hour and one square foot of water radiation shall be considered equal to the emission of 150 B.t.u. per hour.
    B. Heating surface shall be expressed in square feet and include those surfaces in the boiler which are exposed to products of combustion on one side and water on the other. The outer surface of tubes shall be used.
    C. Grate area shall be considered as the area of the grate surface expressed in square feet and measured in the plane of the top surface of the grate. For double grate boilers the grate area shall be considered as the area of the upper grate plus ¼ the area of the lower grate.
    D. Furnace volume shall be considered as the cubical content of the furnace between the top of the base or the normal grate line and the plane of entry into or between the tubes plus the net base volume under the firebox. The net base volume shall be determined by deducting the volume of the refractory lining from the gross volume under the firebox.

The Measurement of the Flow of Air Through Registers and Grilles

By Lynn E. Davies[1], Chicago, Ill.
NON-MEMBER

This paper is the result of Research conducted at Armour Institute of Technology in cooperation with the Research Laboratory of the A. S. H. V. E. and The Ventilating Contractors Employers Association of Chicago.

FOR several years doubt has existed as to the proper or most accurate method of measuring the flow of air through grilles or registers. The fact that several methods were being used and that these various methods indicate widely different results gave rise to many controversies. Considerable financial loss resulted in many cases where the fulfillment of a contract was dependent upon these measurements. The laboratories of the Armour Institute of Technology, in cooperation with the Research Laboratory of the A. S. H. V. E. and the *Ventilating Contractors Employers Association of Chicago,* undertook an investigation of the problem in an attempt to arrive at a simple and accurate method of making such measurements.

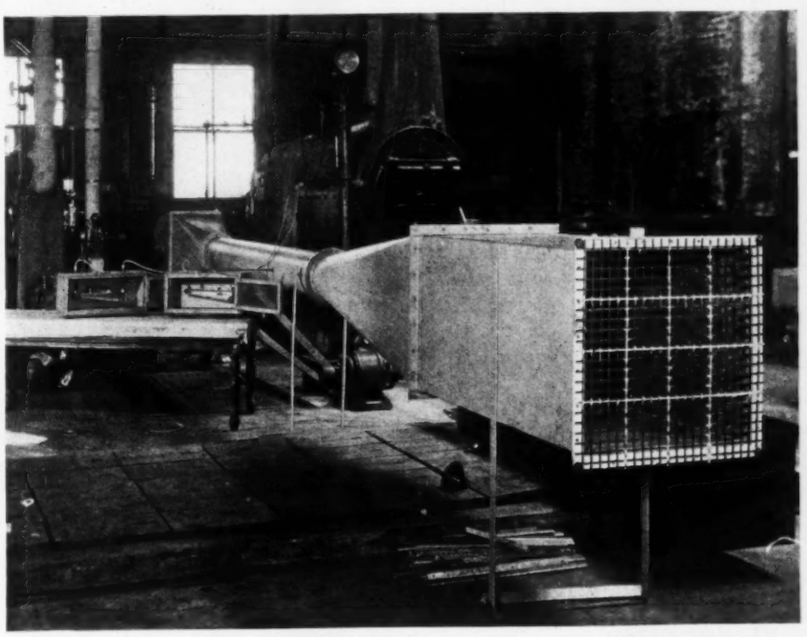

FIG. 1—VIEW SHOWING ORIGINAL SETUP OF APPARATUS

It is apparent that a simple field test is desirable, one that is applicable to the ordinary ventilating system already installed and of such character as to cause little or no interference with the normal operation of the system. Hence, only two types of instruments need be considered at this time, the Pitot tube and the anemometer.

The nature of the air flow coming from a grille is such that no accuracy can be expected from the use of the Pitot tube. Furthermore, the velocities encountered are usually so low that it would necessitate the use of a gage several times more accurate than the usual type of portable instrument. Such sensitive gages are only practical for use in laboratories. It is therefore necessary to use the anemometer and the problem resolves itself into one of how to use this instrument and how properly to interpret its indications.

Supply Registers

Apparatus: The apparatus used in conducting these tests is shown in the accompanying sketches and photographs. It will be noted (Figs. 1 and 2) that in the original set-up the air from a centrifugal fan was passed through a transformation section into a 10-in. round duct 8 ft. 3 in. in length. On the end of this round duct was a second transformation section 6 ft. in length leading to a straight duct 4 ft. in length and 2 ft. square. In some of the tests the grilles were mounted on the end of this straight square duct. For the other runs an elbow or branched duct was connected to the end of the straight duct, and the grilles fastened on the opposite end of these units as shown in the photographs. (See Figs. 3 and 4.) The two branch ducts used were exactly alike in size and shape except that one contained a fixed vertical split starting two-thirds of the way from one side of the entrance to the duct, while the other contained a movable vertical split. Each of these branch ducts contained two outlets, 16 in. by 24 in. and 8 in. by 24 in. respectively. The entire system from fan to grille was made air-tight and particular care was taken to have the section of round duct smooth and uniform in size and shape.

After approximately half of the runs had been made, a large plenum chamber was added between the fan and the 10-in. duct. The entrance end of this chamber

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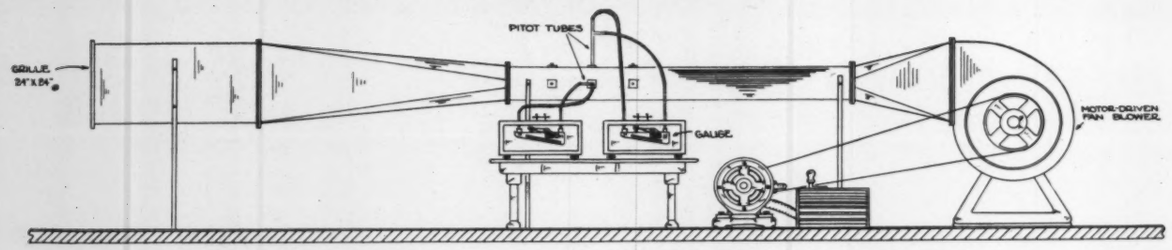


FIG. 2—ELEVATION SHOWING ORIGINAL APPARATUS AND FAN TRANSFORMATION SECTION, ROUND DUCT, SECOND TRANSFORMATION SECTION AND STRAIGHT DUCT

was fitted with grilles similar to those being tested. These served to destroy the initial high velocity given to the air by the fan and to create a static condition in the discharge end of the chamber which would be favorable to the production of uniform parallel flow at the Pitot tubes. Although the Pitot tube readings were steadier after the addition of this chamber, the final results were not changed in any way.

Traverses were made in the round section 6 ft. 3 in. from the blower end, with standard type Pitot tubes. Two traverses (horizontal and vertical) of 10 readings each were made for every anemometer traverse. The amount of air flow, as measured by these Pitot tubes, will hereafter be referred to as the *correct* or *actual* air flow. During the course of the work three different anemometers were used, each newly calibrated by the Bureau of Standards. All three instruments were of the same type.

Procedure: The surface of each grille was marked off into a number of equal rectangular areas, 16 divisions in the case of the 24 x 24 in. grilles, 12 in the case of the 16 x 24 in. grilles, and 4 in the case of the smallest grilles used. During each run two readings were taken with the anemometer opposite the center of each small area. One of these readings in each case was taken with the anemometer held in contact with the surface of the grille, the other with the instrument held 3 in. away. In each case the average of the 16 readings obtained was corrected for instrument error and then multiplied by the gross area of the grille. Similarly each corrected average velocity was multiplied by the net free area. This resulted in five values for the air flow for each run, namely:

1. Anemometer reading in contact multiplied by gross area.
2. Anemometer reading in contact multiplied by net free area.
3. Anemometer reading 3 in. away multiplied by gross area.
4. Anemometer reading 3 in. away multiplied by net free area.
5. Quantity as measured by Pitot tubes.

TABLE 1—DESCRIPTION OF GRILLES TESTED

1. Expanded metal lath having diamond shaped openings measuring 2 in. by 0.932 in. across the corners.	
Percentage of free area	72.0
2. Plain lattice work	
Size of openings	0.95 in. square
Spacing—center to center	1.19 in.
Thickness	1/16 in.
Percentage free area	63.25
3. Plain lattice work	
Size of openings	0.875 in. square
Spacing—center to center	1.125 in.
Thickness	1/16 in.
Percentage free area	69.5
4. Plain lattice work	
Size of openings	0.75 in. square
Spacing—center to center	1.00 in.
Thickness	1/16 in.
Percentage free area	56.25
5. Plain lattice work	
Size of openings	0.50 in. square
Spacing—center to center	0.75 in.
Thickness	1/16 in.
Percentage free area	44.44
6. Iron plate 3/8 in. thick round holes	
Diameter	0.73 in.
Percentage of free area	38.2

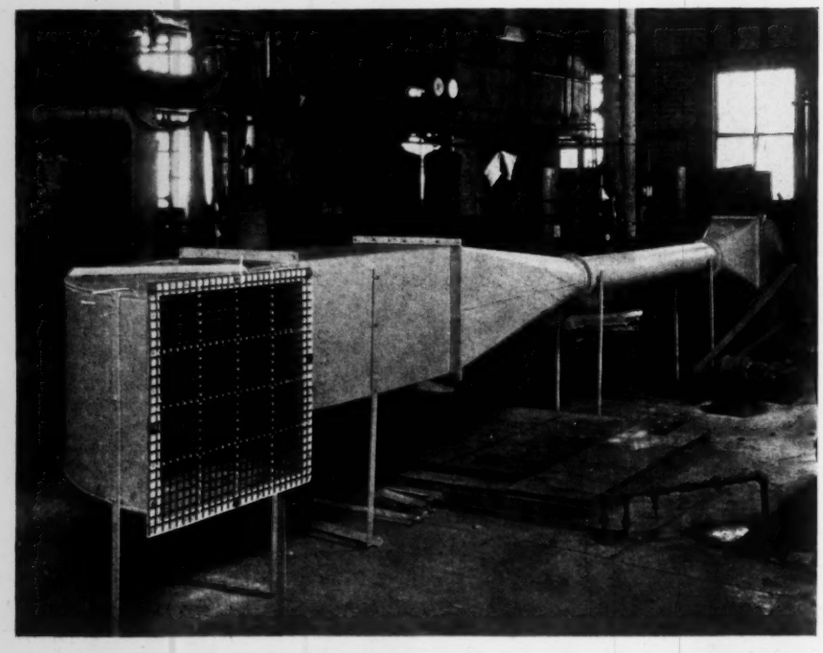


FIG. 3—VIEW SHOWING ELBOW AND GRILLE CONNECTED TO STRAIGHT DUCT

By comparing the results obtained by the first four calculations, with the result of the Pitot tube traverse, it is possible to determine which method, if any, is the correct one for calculating the volume of air from the indicated velocities shown by the anemometer.

Discussion of Results: When the instrument is held in contact with the grille, the face of the anemometer is

TABLE 2—RESULTS OBTAINED WHEN ANEMOMETER WAS HELD IN CONTACT WITH THE GRILLE AND THE VELOCITY INDICATED WAS MULTIPLIED BY THE GROSS AREA

POSITION OF ANEMOMETER.....IN CONTACT WITH GRILLE
AREA USED.....GROSS AREA OF GRILLE

GRILLE USED, % FREE AREA	DUCT USED	AVERAGE VELOCITY INDICATED BY ANEMOMETER, FEET PER MINUTE	AIR FLOW CALCULATED FROM ANEMOMETER *c. f. m.*	ACTUAL AIR FLOW, *c. f. m.* (PITOT TUBE)	RATIO OF CALCULATED FLOW TO ACTUAL FLOW, %
72.0	*S*	242	968	800	121.0
63.25	*S*	757	3028	2467	123.0
		744	2976	2392	124.5
		540	2160	1691	127.5
56.25	*S*	766	3064	2330	131.5
		529	2116	1619	131.0
		268	1072	813	132.0
44.44	*S*	765	3060	2261	135.0
		538	2152	1545	139.0
		286	1144	805	142.0
63.25	*E*	713	2852	2390	119.0
		515	2060	1697	121.5
56.25	*E*	759	3036	2330	130.0
		530	2120	1615	131.0
44.44	*E*	756	3024	2200	138.5
		559	2236	1589	141.0
60.5	*BV*	318	849 } 1071	822.5	130.2
		167	222 }		
60.5	*BV*	218	581 } 1050	806.0	130.0
		352	469 }		
56.25	*B*	540	1440 } 2164	1685	129.0
		543	724 }		
56.25	*B*	440	1173 } 1730	1300	133.0
		410	547 }		
56.25	*B*	298	795 } 1157	860	134.5
		272	362 }		
44.44	*B*	364	971 } 1438	1026	140.0
		350	467 }		
44.44	*B*	245	653 } 976	669	146.0
		242	323 }		

not subjected to a uniform flow of air over its entire area, but instead is exposed to a group of small jets divided by regions of dead, low velocity, or turbulent air. The portion of the area touched by the jets is probably approximately equal to the percentage of free area of the grille. To maintain that *Method 1* is correct is to claim, in effect, that an anemometer exposed to a variable velocity across its face indicates the true average velocity. This may appear to be a perfectly reasonable assumption, but those who are familiar with the action of anemometers know that they always indicate a value nearer to the maximum than to the minimum, and therefore somewhat higher than the average. The results obtained by this method, therefore, will probably be too high.

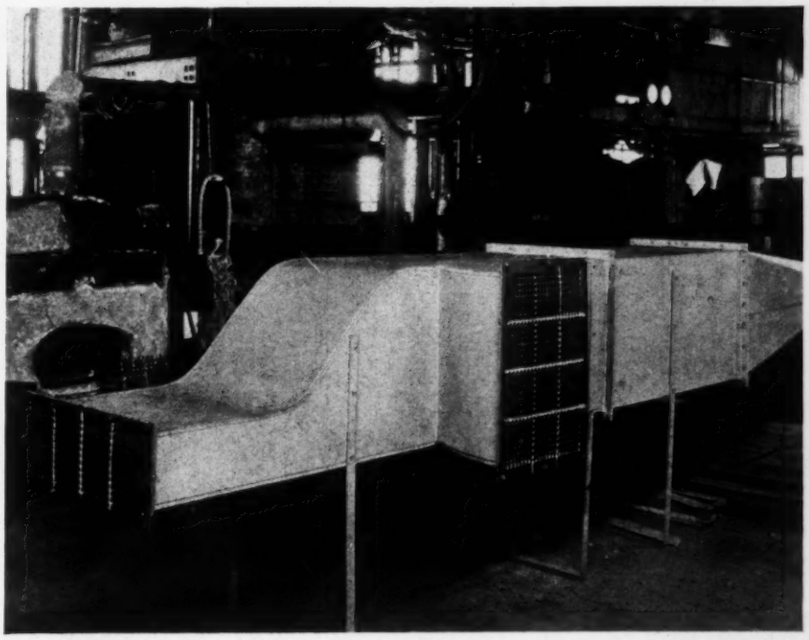


FIG. 4—VIEW SHOWING BRANCHED DUCT CONNECTED TO STRAIGHT DUCT

Method 2 would be correct if the anemometer indicated the maximum velocity striking the blades. This is not the case because in the regions of low velocities the vanes act as a propeller, drawing the air forward, and this action naturally imposes a load on them which reduces their speed of rotation. This method may, therefore, be expected to give results which are too small.

Method 3 appears to be more nearly correct than the others if the instrument is held sufficiently far away to have the individual jets blend together into a solid stream of uniform velocity. The results indicate that 3 in. is not sufficient to accomplish this objective.

Method 4 does not require consideration, since it is apparent that a value lower than with Method 2 is obtained and which is too small.

Table 1 gives a description of the types of grilles tested. Table 2 shows the results obtained when the anemometer was held in contact with the grille and the velocity indicated was multiplied by the gross area. It will be noted that the results obtained were from 19 per cent to 46 per cent too high, varying somewhat with the velocity and to a much greater extent with the amount of free area. Table 3 shows the results obtained when the anemometer readings were multiplied by the net free area of the grille. In this case the results were from 13 per cent to 40 per cent too low. This is of particular interest because it is probable that this method has been used more than any of the others. Tables 4 and 5 show the results obtained from similar calculations based on readings taken 3 in. from the face of the grille. Here the errors ranged from + 10 per cent to + 36 per cent when the gross area was used, and from —27½ per cent to —44 per cent when the net area was used.

These results show plainly the urgent need for more accurate formulae than any heretofore used. Refer-

ring again to Tables 2 and 3, a close observation of the results shown in the right hand columns discloses the fact that for corresponding runs the percentage of error in the two cases is approximately equal. This suggested the use of a new formula:

$$c.f.m. = \frac{V(A+a)}{2} \text{ or } \frac{VA(1+p)}{2} \quad (1)$$

in which

V = corrected average anemometer reading taken in contact with grille, in feet per minute.
A = gross area of grille, square feet.
a = net free area of grille, square feet.
p = percentage of free area of grille expressed as a decimal.

Table 6 shows the results of applying this formula. It will be noted that the maximum error was 5 per cent and that this could have been still further reduced had a coefficient of 0.98 been introduced into the formula. In view of the fact that the work, so far, has been confined to a limited number of types of grilles, it appears desirable that a coefficient C be introduced into the formula to provide for a variation in results which may occur when different type of grilles are investigated. The formula will then become

$$c.f.m. = \frac{CV(A+a)}{2} \text{ or } \frac{CVA(1+p)}{2} \quad (2)$$

It is the opinion of the author that the use of a constant value of 1.00 or 0.98 for C will introduce less error than that encountered from other sources such as errors in calculating free area, carelessness in making traverses, the difficulty of securing true average velocities when the distribution is poor, and the use of anemometers which are inaccurate due to careless handling or long use without calibration. For securing the highest possible degree of accuracy, however, the results may be analyzed to determine what factors are most important in establishing the value of C to be used in this new formula. The average value of C obtained for each grille is as follows:

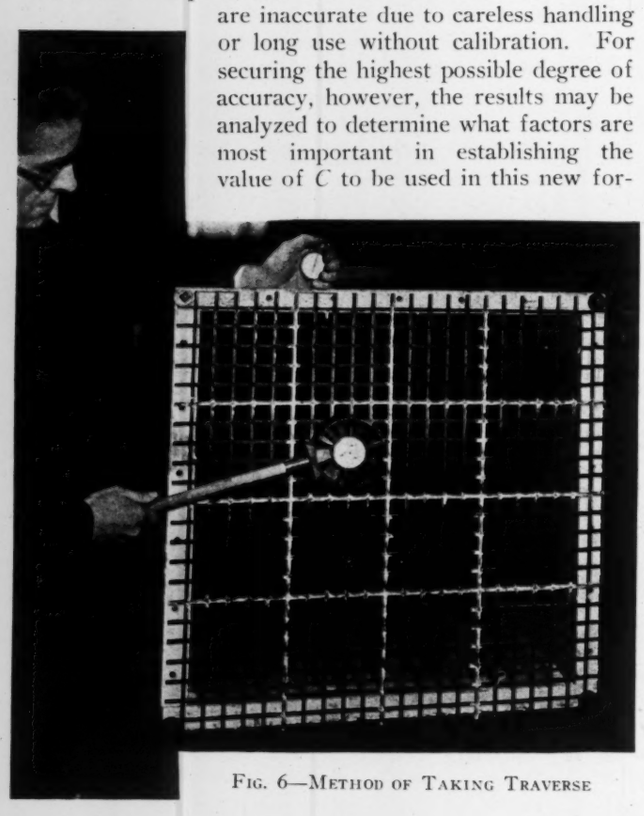


FIG. 6—METHOD OF TAKING TRAVERSE

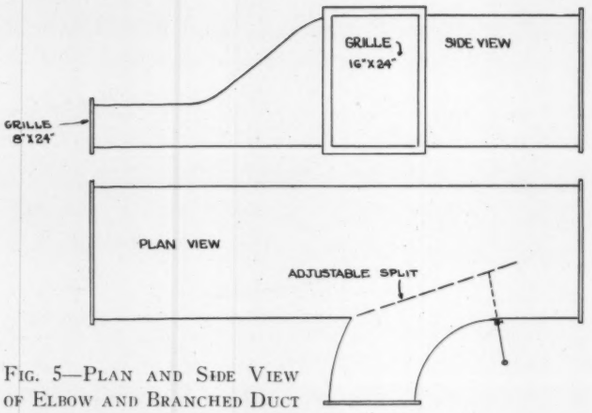


FIG. 5—PLAN AND SIDE VIEW OF ELBOW AND BRANCHED DUCT SHOWING ADJUSTABLE SPLIT

GRILLE	PER CENT FREE AREA	AVERAGE VALUE OF C
1	72.0	0.956
2	63.25	0.995
3	60.50	0.958
4	56.25	0.976
5	44.45	0.985

The results appear to be somewhat erratic, but it is observed that No. 1 and No. 3 were tested only with relatively low air velocities, and while No. 2 was only tested with the higher velocities the results appear more logical. It is evident that the percentages of free area do not affect the value of C for the types of grilles investigated. A careful study of Table 6 will show that the highest values of C were secured with the highest velocities, and the lowest values with the lowest velocities. It appears then that the air velocity is a definite factor causing the variation in the value of the coefficient. The following values of C for the various velocities were obtained by means of the curve, Fig. 7:

INDICATED AIR VELOCITY FEET PER MINUTE	C
150	0.952
200	0.957
300	0.967
400	0.977
500	0.985
600	0.992
700	0.998
800	1.000

In practice the velocity of the air coming from a register often varies greatly at different positions across its face. It is of interest to note, therefore, the amount of velocity variation encountered in this test. This is shown in Table 7. The last set of figures shown are of particular interest because of the exceptionally high variation. This was caused by the fact that the air had to pass from a 5½ in. x 24 in. opening at the split to a 16 in. x 24 in. discharge in a very short distance and while making a short radius turn. This resulted in the air issuing from the grille at a distinct angle and with a

TABLE 3—RESULTS OBTAINED WHEN THE ANEMOMETER WAS HELD IN CONTACT WITH THE GRILL AND THE READINGS WERE MULTIPLIED BY THE NET FREE AREA OF THE GRILLE

POSITION OF ANEMOMETER.....IN CONTACT WITH GRILLE
AREA USED.....NET FREE AREA OF GRILLE

GRILLE USED, % FREE AREA	DUCT USED	AVERAGE VELOCITY INDICATED BY ANEMOMETER, FEET PER MINUTE	AIR FLOW CALCULATED FROM ANEMOMETER *c. f. m.*	ACTUAL AIR FLOW, *c. f. m.* (PITOT TUBE)	RATIO OF CALCULATED FLOW TO ACTUAL FLOW, %
72.0	*S*	242	696	800	87.0
63.25	*S*	757	1915	2467	78.0
		744	1884	2392	79.5
		540	1365	1691	80.5
56.25	*S*	766	1724	2330	74.0
		529	1190	1619	73.6
		268	604	813	74.3
44.44	*S*	765	1360	2261	60.0
		538	955	1545	61.8
		286	509	805	63.1
63.25	*E*	713	1806	2390	75.5
		515	1300	1697	76.5
56.25	*E*	759	1708	2330	73.5
		530	1192	1615	74.0
44.44	*E*	756	1345	2200	61.0
		559	992	1589	62.0
60.5	*BV*	318	514 } 649	822.5	78.9
		167	135 }		
60.5	*BV*	218	352 } 636	806.0	79.1
		352	284 }		
56.25	*B*	540	810 } 1216	1685	72.1
		543	406 }		
56.25	*B*	440	660 } 968	1300	74.4
		410	308 }		
56.25	*B*	298	447 } 651	860	75.8
		272	204 }		
44.44	*B*	364	430 } 636	1026	62.0
		350	206 }		
44.44	*B*	245	288 } 431	669	64.5
		242	143 }		

very low velocity along one side. In spite of these unfavorable conditions the coefficient agrees with the average value found on the branched duct with the fixed split, in which case a very favorable velocity distrbution was obtained.

With some kinds of grilles it is difficult to estimate or measure accurately the percentage of free area. It is interesting to note the effect on the final result of an error of this kind. It is best illustrated by an example. Assume that a certain grille has a true free area amount to 50 per cent of the gross area, but through some error is figured as 45 per cent free area. This represents an error in measurement amounting to 10 per cent and if used in the old formula (indicated velocity x free area) would result in a 10 per cent error in volume of air in addition to the already large error due to the formula itself being incorrect. Using the new formula:

With 50 per cent area—

TABLE 4—RESULTS OBTAINED WHEN READINGS WERE TAKEN 3 IN. FROM THE FACE OF THE GRILLE AND THE VELOCITY MULTIPLIED BY THE GROSS AREA

POSITION OF ANEMOMETER.....3 IN. FROM GRILLE
AREA USED.....GROSS AREA OF GRILLE

GRILLE USED, % FREE AREA	DUCT USED	AVERAGE VELOCITY INDICATED BY ANEMOMETER, FEET PER MINUTE	AIR FLOW CALCULATED FROM ANEMOMETER *c. f. m.*	ACTUAL AIR FLOW, *c. f. m.* (PITOT TUBE)	RATIO OF CALCULATED FLOW TO ACTUAL FLOW, %
63.25	*S*	680	2720	2392	114.0
		485	1940	1691	114.5
56.25	*S*	684	2736	2330	117.5
		474	1856	1619	115.0
44.44	*S*	712	2848	2261	126.0
		493	1972	1545	127.5
63.25	*E*	658	2632	2390	110.0
		479	1916	1697	113.0
56.25	*E*	703	2812	2330	121.0
		490	1960	1615	115.5
44.44	*E*	733	2932	2200	133.0
		540	2160	1589	136.0

$$c.f.m.=\frac{VA\ (1+p)}{2}=\frac{VA(1+0.50)}{2}=0.75\ VA$$

With 45 per cent area—

$$c.f.m.=\frac{VA\ (1+p)}{2}=\frac{VA(1+0.45)}{2}=0.725\ VA$$

$$\text{Error}=0.025\ VA$$

$$\text{Percentage Error}=\frac{0.025\ VA}{0.75}\text{x}100=3.33 \text{ per cent}$$

TABLE 5—RESULTS OBTAINED WHEN THE READINGS WERE TAKEN 3 IN. FROM THE FACE OF THE GRILLE AND THE VELOCITY INDICATED MULTIPLIED BY THE NET FREE AREA OF THE GRILLE

POSITION OF ANEMOMETER.....3 IN. FROM GRILLE
AREA USED.....NET FREE AREA OF GRILLE

GRILLE USED, % FREE AREA	DUCT USED	AVERAGE VELOCITY INDICATED BY ANEMOMETER, FEET PER MINUTE	AIR FLOW CALCULATED FROM ANEMOMETER *c.f.m.*	ACTUAL AIR FLOW, *c.f.m.* (PITOT TUBE)	RATIO OF CALCULATED FLOW TO ACTUAL FLOW, %
63.25	*S*	680	1720	2392	72.0
		485	1228	1691	72.5
56.25	*S*	684	1539	2330	66.0
		474	1066	1619	66.0
44.44	*S*	712	1265	2261	56.0
		493	875	1545	56.5
63.25	*E*	658	1665	2390	69.5
		479	1210	1697	71.0
56.25	*E*	703	1582	2330	68.0
		490	1102	1615	68.5
44.44	*E*	733	1301	2200	59.2
		540	960	1589	60.5

TABLE 6—RESULTS OF APPLICATION OF FORMULA (1)

Position of Anemometer.....In contact with grille
Area used.....Gross area + Net area

$$C = \frac{\text{Actual Air Flow}}{\text{Anemometer Reading} \times \text{Area}^{2}}$$

Grille used, % free area	Duct used	Average Velocity indicated by Anemometer Feet per Minute	Air Flow calculated from Anemometer $c.f.m.$	Actual Air flow, $c.f.m.$ (Pitot Tube)	Ratio of calculated flow to actual flow, %	C
72.0	S	242	835	800	104.4	0.957
63.25	S	757	2471	2467	100.1	0.999
		744	2430	2392	101.6	0.985
		540	1762	1691	104.1	0.961
56.25	S	766	2394	2330	102.5	0.976
		529	1653	1619	102.1	0.978
		268	838	813	103.0	0.971
44.44	S	765	2210	2261	97.7	1.021
		538	1553	1545	100.6	0.994
		286	825	805	102.5	0.977
63.25	E	713	2329	2390	97.5	1.027
		515	1680	1697	99.1	1.009
56.25	E	759	2372	2330	101.8	0.983
		530	1656	1615	102.5	0.977
44.44	E	756	2184	2200	99.5	1.005
		559	1614	1589	101.8	0.983
60.5	BV	318	682 } 860	822.5	104.2	0.959
		167	178 }			
60.5	BV	218	466 } 843	806.0	104.2	0.959
		352	377 }			
56.25	B	540	1152 } 1600	1685	100.3	0.997
		543	565 }			
56.25	B	440	916 } 1343	1300	103.0	0.971
		410	427 }			
56.25	B	298	621 } 904	860	105.0	0.953
		272	283 }			
44.44	B	364	700 } 1036	1026	101.0	0.990
		350	336 }			
44.44	B	245	470 } 703	669	105.0	0.953
		242	233 }			

Thus it is apparent that the 10 per cent error in measurement only causes a 3-1/3 per cent error in the value of $c.f.m.$

Exhaust Registers

Apparatus: For the purpose of investigating the performance of the anemometer on exhaust registers the same apparatus was used except that the test duct was connected to the suction side of the fan. All of the work was done with the straight duct as it appeared that the shape of the duct would have little if any effect in this case.

Method: The general procedure was the same as before except that all of the anemometer traverses were made in contact with the grille. The nature of the air stream surrounding an exhaust grille is very different from that surrounding a supply grille. The air around the exhaust register is being drawn in from all sides as well as straight from the front, so that an anemometer traverse made in front of the opening but some distance away would only show a portion of the total flow. The percentage of the total thus effecting the anemometer would vary greatly with the total area of the grille, its shape and the nature of the surrounding wall surface. It therefore appears essential that the traverse be made as close to the surface of the grille as practical.

Discussion of Results

Table 8 shows the results obtained when the anemometer readings were multiplied by the net free area of the grille. It will be noted that the error amounted to from 7.3 per cent to 51.6 per cent, a much wider variation than that obtained with supply grilles when the same formula was used. Table 9 shows the results of applying the new formula (1). It can be seen that the results vary more than was the case with the supply systems. The results can be more clearly visualized by Fig. 8 on which the value of C has been plotted against the velocities shown by the anemometer for each grille.

The great difference between the *38.2 per cent* and the *44.44 per cent* curves and the *63.25 per cent* and *72 per cent* curves indicate that, unlike the case of supply grilles, the values of C vary not only with the velocity, but also with the percentage of free area and the type of grille. The 38.2 per cent grille had solid metal between the openings measuring approximately 0.45 in. x 1.2 in. which is more than is encountered in the average grille, while the 72 per cent grille was of expanded metal lath measuring approximately 1/8 in. across the frets and having the edges pointed in the direction of the air flow. It is probab'e that these two styles represent the greatest extremes likely to be encountered in practice.

For the velocity range from 150 $f.p.m.$ to 700 $f.p.m.$ the maximum value of C is 1.145 while the minimum value is 0.90. If a constant value of 1.02 is used, there will be a possible maximum error of 12.5 per cent although usually the error will be considerably less.

Since the value of C does not seem to follow any ra-

TABLE 7—VARIATION IN VELOCITY AT DIFFERENT POSITIONS ACROSS THE FACE OF THE GRILLE

Duct used	Grille used, % free area	Variation of Velocity Across Grille expressed as ratio between maximum and minimum velocities for any one run. Max. Variation	
Straight	72.0	2.04	
	63.25	1.53	
	56.25	1.38	
	44.44	1.24	
Elbow	63.25	1.62	
	56.25	1.35	
	44.44	1.27	
		Small Branch	Large Branch
Branched Fixed Split	56.25	1.06	1.25
	44.44	1.11	1.085
aBranched Adjustable Split No. 1	60.25	1.14	1.32
aBranched Adjustable Split No. 2	60.25	1.10	5.94

aFor Run No. 1 the split was moved over to a point 2 in. from the wall leading to the small outlet.
For Run No. 2 the split was moved to a position 5½ in. from the wall leading to the large outlet.

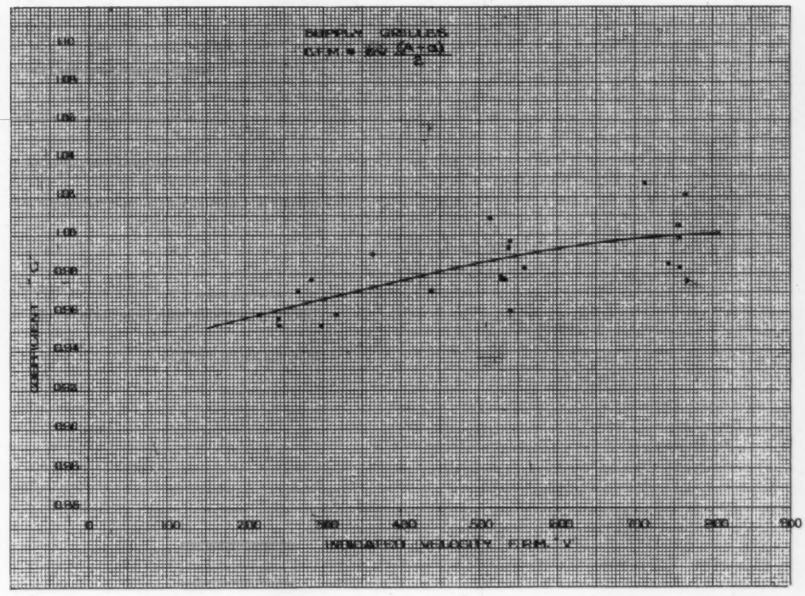


FIG. 7—CURVES SHOWING RELATION BETWEEN INDICATED VELOCITY AND COEFFICIENT *C* FOR SUPPLY GRILLES

tional law as to the type of grille, it appears that the only alternative is to draw an average curve as shown by the dotted line of Fig. 8. This has been drawn somewhat higher than half way between the extreme curve, but appears to be a better one for the average type of grille. From this curve, the factors shown in the table to the left can be obtained.

INDICATED AIR VELOCITY FEET PER MINUTE	*C*
150	0.993
200	1.005
300	1.028
400	1.049
500	1.067
600	1.078
700	1 084

When these values are used there will be a possible error of approximately 10 per cent but will result only under extreme circumstances. In the majority of cases the error will be less than 3 per cent.

Table 10 shows the results obtained when the indicated velocities were multiplied by the gross area of the grille. These show that while there is a variable error, the amount of variation is much less than it was with supply grilles, particularly if values for equal velocities are com-

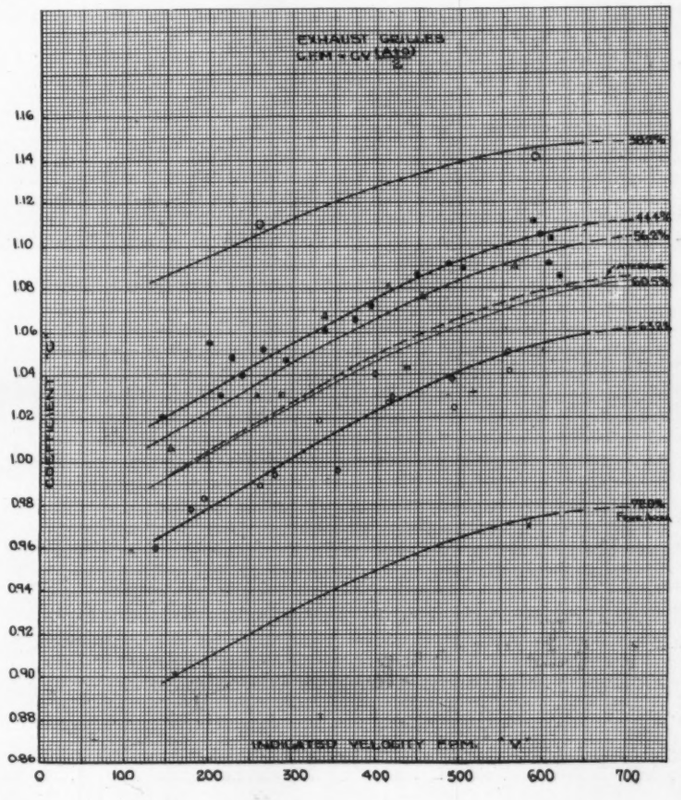


FIG. 8—CURVES SHOWING RELATION BETWEEN INDICATED VELOCITY AND COEFFICIENT *C* FOR VARIOUS PERCENTAGES OF FREE AREA FOR EXHAUST GRILLES

pared. The final column shows the value of the coefficient K which may be used, giving the formula:

$$c.f.m. = K\ V\ A \qquad (3)$$

in which

V = Indicated velocity in feet per minute.

A = Gross area, square feet.

Fig. 9 shows the values of K plotted against velocity for various grilles. It will be noted that if a constant value of 0.8 is used for K the maximum error will be 7½ per cent while if an average curve is drawn, as before, and a factor varying with the velocity applied, the resulting error will be reduced to a maximum of less than 4 per cent. The values of K in this case would be as shown at the top of the first column on the next page.

It is possible that a further study of these figures may

TABLE 8—RESULTS OBTAINED WHEN ANEMOMETER READINGS WERE MULTIPLIED BY THE NET FREE AREA OF THE GRILLE

Position of Anemometer ..... In contact with grille
Area used ..... Net Free Area

Grille used, % free area	Average Velocity indicated by Anemometer, Feet per Minute	Air Flow calculated from Anemometer reading, *c.f.m.*	Actual Air Flow, *c.f.m.* (Pitot Tube)	Ratio of calculated flow to actual flow %
72.0	160	461	497	92.7
	448	1290	1478	87.3
	583	1676	1942	86.2
63.25	136	344	425	80.9
	180	455	575	79.1
	195	494	627	78.6
	261.6	664	845	78.5
	278.7	705	905	78.0
	332	840	1108	76.0
	354.5	895	1152	77.6
	399	1010	1360	74.2
	413	1047	1398	74.9
	418	1059	1408	75.1
	490	1240	1661	74.6
	494	1250	1652	75.6
	556	1410	1910	73.9
	559.5	1412	1903	74.2
60.5	286	693	945	73.4
	435.5	1053	1460	72.1
56.25	155	348	487	71.5
	257	577.5	830	69.5
	338	761	1126	66.0
	411	925	1390	66.5
	454	1020	1522	67.0
	565	1270	1925	65.9
44.44	145	257	428	60.0
	200	355.5	610	58.3
	214	380	639	59.5
	226	401	684	58.8
	239.5	425	720	59.0
	265	470	806	58.2
	291	516	880	58.8
	338	600	1038	58.0
	374	665	1155	57.5
	392.5	696.5	1220	57.1
	449	798	1410	56.6
	485	861	1530	56.4
	501	890	1575	56.5
	586	1040	1882	55.5
	595	1057	1898	55.7
	605	1072	1910	56.3
	607	1078	1935	55.6
	618.5	1098	1940	56.5
38.2	260	397	800	49.6
	590	904	1870	48.4

TABLE 9—APPLICATION OF RESULTS TO FORMULA (2)

Position of Anemometer ..... In contact with grille
Area used ..... Gross area + Net area / 2

Grille used, % free area	Average Velocity indicated by Anemometer Feet per Minute	Air Flow calculated from Anemometer reading, *c.f.m.*	Actual Air flow, *c.f.m.* (Pitot Tube)	Ratio of calculated flow to actual flow, %	*C*
72.0	160	550.5	497	111.0	0.901
	448	1541	1478	104.1	0.959
	583	2004	1942	103.1	0.97
63.25	136	444	425	104.1	0.96
	180	587.5	575	102.1	0.978
	195	637	627	101.7	0.983
	261.6	855	845	101.1	0.989
	278.7	909.9	905	100.6	0.994
	332	1084	1108	98.1	1.019
	354.5	1156.5	1152	100.4	0.996
	399	1303	1360	96.0	1.040
	413	1349.5	1398	.....	1.027
	418	1365.5	1408	97.0	1.030
	490	1600	1661	96.3	1.038
	494	1613	1652	97.5	1.025
	556	1817	1910	95.2	1.050
	559.5	1826	1903	95.9	1.041
60.5	286	918.5	945	97.0	103.1
	435.5	1397.5	1460	95.6	104.3
56.25	155	484	487	99.4	1.006
	257	802.7	830	96.7	1.031
	338	1056.5	1126	93.6	1.068
	411	1284.5	1390	92.4	1.081
	454	1418.0	1522	93.0	1.076
	565	1765	1925	91.6	1.09
44.44	145	418.5	428	97.8	1.021
	200	578	610	94.7	1.055
	214	618	639	97.0	1.031
	226	652.5	684	95.5	1.048
	239.5	692	720	96.1	1.040
	265	765	806	94.9	1.052
	291	840	880	95.5	1.047
	338	976	1038	94.2	1.061
	374	1080.5	1155	93.8	1.066
	392.5	1133.5	1220	93.1	1.072
	449	1297	1410	92.0	1.086
	485	1400.5	1530	91.5	1.091
	501	1447	1575	91.8	1.089
	586	1692	1882	90.0	1.111
	595	1718.5	1898	90.5	1.105
	605	1746	1910	91.5	1.091
	607	1753	1935	90.7	1.103
	618.5	1786	1940	92.1	1.085
38.2	260	718.5	800	89.9	1.110
	590	1632	1870	87.5	1.141

INDICATED AIR VELOCITY FEET PER MINUTE	K
150	0.762
200	0.772
300	0.789
400	0.806
500	0.820
600	0.828
700	0.832

disclose another formula involving a constant coefficient with smaller maximum errors than those encountered with the two considered. For example, the following might prove satisfactory.

$$c.f.m. = C'V\ (0.8A + 0.2a)$$

A formula of this character would, of course, not eliminate the small change in C caused by the change in velocity. Any formula that would attempt to correct for this variable would be a quadratic containing a factor of the form $(V+V^n)$ in which n would be a value less than 1. It is the author's opinion that the use of any such complicated formula is unwarranted under the circumstances.

The results of these tests are summarized in Table 11. All of the curves for the various coefficients appear to approach the horizontal as the velocity is increased. Lack of proper equipment has prevented verifying this fact, but it is expected that this can be done in the near future.

It is frequently asked if it is necessary to apply an anemometer correction to each individual reading when a number of spot readings are taken as was the case in these experiments. If the actual velocity is plotted against the indicated velocity, the curve obtained will be a straight line in most cases, and it is therefore mathematically correct to use the average of the various velocities as read and to then apply a single correction factor. Furthermore, it is possible to extend this straight line below the lowest point obtained by actual calibration with entirely consistent results.

The question most frequently asked is that regarding

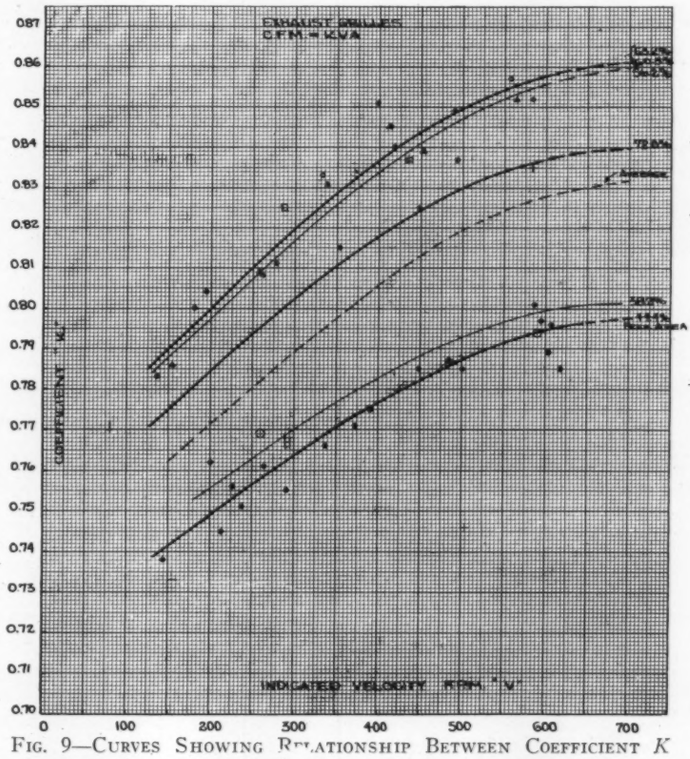


FIG. 9—CURVES SHOWING RELATIONSHIP BETWEEN COEFFICIENT K AND INDICATED VELOCITY FOR VARIOUS PERCENTAGES OF FREE AREA FOR EXHAUST GRILLES

TABLE 10—RESULTS OBTAINED WHEN INDICATED VELOCITIES WERE OBTAINED BY THE GROSS AREA OF THE GRILLE

POSITION OF ANEMOMETER ..... IN CONTACT WITH GRILLE
AREA USED ..... GROSS AREA

GRILLE USED, % FREE AREA	AVERAGE VELOCITY INDICATED BY ANEMOMETER FEET PER MINUTE	AIR FLOW CALCULATED FROM ANEMOMETER READING, $c.f.m.$	ACTUAL AIR FLOW, $c.f.m.$ (PITOT TUBE)	RATIO OF CALCULATED FLOW TO ACTUAL FLOW, %	K
72.0	160	640	497	1.288	0.776
	448	1792	1478	1.21	0.825
	583	2332	1942	1.20	0.835
63.25	136	544	425	1.277	0.783
	180	720	575	1.250	0.800
	195	780	627	1.241	0.804
	261.6	1046.5	845	1.238	0.808
	278.7	1115	905	1.230	0.811
	332	1328	1108	1.200	0.833
	354.5	1418	1152	1.229	0.815
	399	1596	1360	1.172	0.851
	413	1652	1398	1.181	0.845
	418	1672	1408	1.19	0.840
	490	1960	1661	1.18	0.849
	494	1976	1652	1.192	0.837
	556	2224	1910	1.167	0.857
	559.5	2238	1903	1.172	0.852
60.5	286	1144	945	121.1	0.825
	435.5	1742	1460	119.2	0.837
56.25	155	620	487	127.0	0.786
	257	1028	830	123.5	0.809
	338	1352	1126	118.1	0.845
	411	1644	1390	118.1	0.845
	454	1816	1522	119.0	0.839
	565	2260	1925	117.2	0.852
44.44	145	580	428	135.3	0.738
	200	800	610	131.0	0.762
	214	856	639	134.1	0.745
	226	904	684	132.1	0.756
	239.5	958	720	133.0	0.751
	265	1060	806	131.2	0.761
	291	1164	880	132.2	0.755
	338	1352	1038	130.5	0.766
	374	1496	1155	129.5	0.771
	392.5	1570	1220	129.0	0.775
	449	1796	1410	127.1	0.785
	485	1940	1530	127.0	0.787
	501	2004	1575	127.1	0.785
	586	2344	1882	124.8	0.801
	595	2380	1898	125.2	0.797
	605	2420	1910	126.9	0.789
	607	2428	1935	125.5	0.796
	618.5	2474	1940	127.3	0.785
38.2	260	1040	800	130.0	0.769
	590	2360	1870	126.0	0.794

TABLE 11—SUMMARY OF RESULTS

AVERAGE INDICATED VELOCITY, $f.p.m.$	$c.f.m. = \frac{CV(A+a)}{2}$ SUPPLY GRILLES C	$c.f.m. = \frac{CV(A+a)}{2}$ EXHAUST GRILLES C	$c.f.m. = KVA$ EXHAUST GRILLES ONLY K
150	0.952	0.993	0.762
200	0.957	1.005	0.772
300	0.967	1.028	0.789
400	0.977	1.049	0.806
500	0.985	1.067	0.820
600	0.992	1.078	0.828
700	0.998	1.084	0.832
800	1.000		
Factor for average use	low vel. 0.97 high vel. 1.00	1.02	0.8

Note:
A = gross area of grille—square feet
a = net free area of grille—square feet
Each table of coefficients approaches a constant value as the velocity is increased so that it is believed that the use of the highest value shown in each case can be used for all higher velocities with very slight error.

the feasibility of making a traverse by moving the instrument over the face of the grille, thus securing a single reading instead of a number of spot readings. Check readings were frequently made in this manner throughout these tests and quite satisfactory results were secured. The greatest error is likely to result when there is a wide variation in velocity across the face of the grille. When the instrument is observed to be slowing up in a region of low velocity there is a natural tendency to move it quickly to a region of higher velocity. For this reason the moving traverse is liable to give results that are somewhat too high under these circumstances. This can be at least partly overcome if, before starting to run, a mental note is made of the time which should have elapsed when certain points in the traverse are reached.

With grilles the size of those used in these tests, such a run should be of at least two minutes duration unless the velocity is exceptionally uniform throughout the entire region traversed.

It is the opinion of the author that the data so far secured will make it possible to make anemometer measurements with a far greater degree of accuracy than has been possible in the past.

Amendments to By-Laws of the American Society of Heating and Ventilating Engineers

In accordance with the provisions of the By-Laws relating to Amendments the following amendments are presented by the Council for vote at the Annual Meeting, Jan. 28, 1930.

ARTICLE XIII—Funds.

Section 1. All funds and moneys shall be received, deposited, invested and disbursed under the direction of the Council.

Section 2. When so directed by the Council, the Chairman of the Finance Committee, shall invest such portion of any funds of the Society as determined by the Council in securities legal for the investment of funds of savings banks of the State of New York. All investments shall be approved by the Council.

Section 3. Any bequest or gift to the Society which the donor shall designate to be used for a specific purpose shall, after acceptance by the Council, be deposited or invested in the manner provided by Sections 1 and 2, and the income or principal, as designated by the donor, used for the specific purpose designated.

Section 4. An endowment fund for research and such other purposes devoted to the art of heating and ventilating as may be determined by the Council shall be established. The interest or income from this fund shall be used each year as shall be determined by the Council. The principal shall remain intact and shall be deposited in banks or invested in securities legal for the investment of funds of savings banks of the State of New York, as determined by the Council in the manner provided by Sections 1 and 2.

Section 5. At the beginning of each year the Finance Committee shall present to the Council a budget of estimated income and expenditures for the current year, which after approval by the Council shall govern the expenditure of Society funds for that year. Any expenditure of Society funds outside of the approved budget shall be approved by the Council before the expenditure is made.

Section 6. Any money due the Society shall be collected by the Secretary, who shall enter all receipts in the books of the Society and deposit same to the Treasurer's account. The Secretary shall receive all bills against the Society, and shall present them for audit and approval to the Chairman of the Finance Committee. The approved bills shall be referred to the Treasurer, which officer, if he also approves the bills, shall draw and sign a check payable to the account of AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS for the total amount of the approved bills. The Treasurer shall present the approved bills with the check to the President of the Society for his examination. After approval of the bills by the President, that officer shall countersign the check in payment thereof, which check shall be deposited to the account of AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and known as the Secretary's account. The Secretary shall promptly draw against this account in settlement of the approved bills. The Secretary shall have the authority to pay salaries, travelling expenses and petty cash in accordance with the budget.

Section 7. After December 31st, and before the annual meeting of the Society in January, the accounts of the Society shall be audited by a certified public accountant, selected by the Council at its last meeting in the calendar year. The auditor's report shall be presented at the annual meeting of the Society by the Chairman of the Finance Committee.

Change number of present Article XIII—AMENDMENTS—to Article XIV.

Repeal *Section* 7 of Article VI, which reads as follows:

Section 7. The Council shall designate the bank or depository in which the funds of the Society shall be deposited and shall by appropriate resolutions designate the purpose for which the funds may be withdrawn and authorize such withdrawal.

Amend Article VII, Section 4, which reads as follows:

Section 4. The Treasurer shall have the custody of all the funds of the Society, and shall deposit them to the credit of the Society in such bank or depository as the Council may designate, and he shall disburse the same as provided in Art. VIII, Section 3. He shall enter regularly in books of the Society to be kept by him for the purpose, full and accurate account of all moneys received and disbursed for the Society. He shall at all reasonable times exhibit his books and accounts to any member of the Council, and shall perform all duties incident to the office of the Treasurer, subject to the control of the Council. He shall give a bond in a penal sum and with a surety or sureties approved by the Council, for the faithful performance of his duties as Treasurer. If a surety company bond is furnished the premiums therefore shall be paid by the Society.

To read:

Section 4. The Treasurer shall have the custody of all the funds of the Society, as provided in Article XIII. He shall at all reasonable times exhibit his books and accounts to any member of the Council, and shall perform all duties incident to the office of the Treasurer, subject to the control of the Council. He shall give a bond in a penal sum and with a surety or sureties approved by the Council, for the faithful performance of his duties as Treasurer. If a surety company bond is furnished the premiums therefore shall be paid by the Society.

Repeal *Section* 5, Article VII, which reads as follows:

Section 5. The accounts of the Treasurer and the books of the Society shall be audited annually by a certified public accountant selected by the Council at least thirty (30) days before the close of the fiscal year.

Repeal *Section* 3, Article VIII, which reads as follows:

Section 3. The Finance Committee shall prepare an annual budget of expenditures for the Society and shall pass upon and approve in writing all expenditures authorized by the Council. No expenditures are to be made by the Secretary, except for salaries, traveling expenses and petty cash, unless authorized by the Chairman of the Finance Committee, on forms provided for that purpose.

In case of disability or absence of the Treasurer the Chairman of the Finance Committee is authorized to sign checks. He shall give bond in the same manner as provided for the Treasurer.

NOMINATIONS FOR OFFICERS OF THE SOCIETY FOR 1930

Your Committee appointed to prepare nominations for Officers of the Society for the coming year, 1930, takes pleasure in submitting the following list of nominees:

For President:

L. A. HARDING, 1335 Main St., Buffalo, N. Y.

For First Vice-President:

W. H. CARRIER, Newark, N. J.

For Second Vice-President:

F. B. ROWLEY, University of Minnesota, Minneapolis, Minn.

For Treasurer:

C. W. FARRAR, Buffalo, N. Y.

For Members of the Council:

Three-Year Term

R. H. CARPENTER, New York, N. Y.
JOHN D. CASSELL, Philadelphia, Pa.
ALFRED KELLOGG, Boston, Mass.
JOHN HOWATT, Chicago, Ill.

Respectfully submitted,

NOMINATING COMMITTEE

FREDERICK D. MENSING, Chairman

C. E. BRONSON
R. C. BOLSINGER
H. B. HEDGES
H. M. NOBIS
JAY R. MCCOLL
O. K. DYER
EDWIN C. EVANS, Sec'y.

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. 9—*Section* 2. The Nominating Committee shall consist of a member designated by each Chapter, which shall effect its own organization and elect is own Chairman.

Section 3. The Committee may meet at the call of the Chairman, for discussion, but the official meeting shall be held at the Semi-Annual Meeting of the Society, at which time the candidates for each of the offices of the Society to be filled at the next Annual Meeting shall be selected by a majority vote of the members of the Committee present and voting. Five shall constitute a quorum.

Section 4. The Committee shall first secure the consent of all candidates selected, and shall if possible announce the names of the candidates at the Semi-Annual Meeting, but in any case the names of the candidates shall be certified to the Secretary of the Society at least four months before the next Annual Meeting. The Secretary shall publish these names in the October issue of THE JOURNAL.

Art. 10.—*Section* 3. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election*. The election is governed by the By-Laws for the election of officers, with the single exception, that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee. In accordance with the Regulations for the government of the Research Laboratory, adopted at the January, 1919, Meeting, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January 1930:

C. V. HAYNES, Philadelphia
W. T. JONES, Boston
J. F. MCINTIRE, Detroit
F. N. SPELLER, Pittsburgh
A. C. WILLARD, Urbana, Ill.

The regulations governing the nomination and election of members of the Committee on Research are as follows:

2. ELECTION.

a. That the Council shall nominate previous to October 1 of each year, five members to fill vacancies of those retiring at the next Annual Meeting.

b. That the nominations made by Council shall be published in the October JOURNAL of the Society.

c. That prior to December 1 of any year, any ten members, over their own signatures, may nominate one or more additional members for the Research Committee, and such additional nominations shall be placed on the ballot opposite such of the nominations made by the Council as designated by those making the nomination.

d. The election shall otherwise conform to the same regulations as are provided for the election of officers.

e. Vacancies may be filled by the Council, such persons, chosen by the Council, to serve until a successor can be elected at the next annual election.

To the Ladies of the American Society of Heating and Ventilating Engineers

The Committee of the Philadelphia Chapter on General Arrangements for the Annual Meeting, have asked me to add to their general invitation a very special one to the ladies of the Society to come to Philadelphia in January to be our guests for the week of January 27th. It has been my personal pleasure to enjoy the delightful hospitality of many of the Chapters and I want to see each one of you here in "Your Philadelphia" that we may in some measure show our appreciation for the many kindnesses to us when we have been your guests. The committee have made a special effort to arrange a program of delightful entertainment for us and I am sure that you will be fully repaid for any effort you may make to attend this meeting.

Cordially yours,

Elsie Van Orden Lewis
(Mrs. Thornton Lewis)

PRESIDENT'S PAGE

To the Members and Friends of the
American Society of Heating and Ventilating
Engineers

Philadelphia extends a hearty welcome and earnest invitation to come to the Thirty-sixth Annual Meeting and International Heating and Ventilating Exposition, the week of January 27, 1930.

There will be many new and novel features to interest you and you will carry away not only valuable information, but the remembrance of an enjoyable week.

Come early and visit the industries of Philadelphia and vicinity engaged in manufacturing heating and ventilating products — see the historical as well as the modern exhibit of equipment relating to this art — attend the annual banquet and dance where there will be presented a number of unusual things to entertain you. There will be no long speeches. Among other things, the Chapter banner will be awarded by the Increase of Membership Committee.

If you fail to attend the Annual Meeting of the Society you lose one of the most valuable assets that belong to you as a member.

This is not the other fellow's business! It is your Society, your Meeting, your Profession and, therefore, your "Business"!

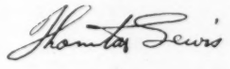
Will you attend to your Business?

What a good and profitable time you can have doing it!

The officers of the Society, the Council, and the Philadelphia Chapter say most cordially

"Welcome to Philadelphia"

December 16, 1929



Philadelphia Ready To Entertain A. S. H. & V. E.

THE PARKWAY EXTENDS FROM THE HEART OF THE CITY AT THE CITY HALL DIRECTLY INTO FAIRMOUNT PARK, THE PARK STRETCHING FOR MILES ALONG BOTH BANKS OF THE SCHUYLKILL RIVER

MEMBERS of the Society will be welcomed to the city of Philadelphia by their friends in the local chapter after an absence of nine years. Headquarters for the 36th Annual Meeting will be at the Benjamin Franklin Hotel, 9th and Chestnut Sts., January 27 to 31, 1930. Pres. Thornton Lewis, Philadelphia, will open the meeting officially on Tuesday morning, January 28, in the Crystal Room of the Benjamin Franklin Hotel.

The entire day on Monday, January 27, has been set aside for council and committee meetings, and to give visiting members an opportunity to visit the manufacturers' plants producing heating and ventilating equipment in Philadelphia and vicinity.

On each day during the week, from noon until 10:30 p.m. (January 27-31), the members can visit the First International Heating and Ventilating Exposition, which will be held in the Commercial Museum, 34th and Pine Sts. Frequent bus service to the Museum will take members and guests from the Hotel.

All arrangements for the meeting have been completed by Chairman R. C. Bolsinger and his committee from the Philadelphia Chapter, and those who visit Philadelphia in January will find a splendid technical and entertainment program for each day. There are some surprises in store for the visiting members, particularly the banquet entertainment program which is scheduled for Thursday evening in the Benjamin Franklin Hotel.

A special letter from the Philadelphia Chapter will be mailed to all members and they are urged to make hotel reservations at an early date. Special cards for this purpose will come to them promptly as well as invitation cards to the Heating and Ventilating Exposition, so that members can invite their friends.

Admittance to the Exposition is by card or registration badge of the A. S. H. & V. E.

Reduced rates for railroad fare on the convention certificate plan have been granted by the railroads and every member who desires to get a reduced fare rate on the return journey *must get a certificate when purchasing ticket to Philadelphia.* This certificate must be turned in at the registration desk in the Benjamin Franklin Hotel for validation. The regulations under which certificates are granted may be seen on the next page.

Philadelphia offers to the visitor an unsurpassed historic background as well as modern industrial and commercial life.

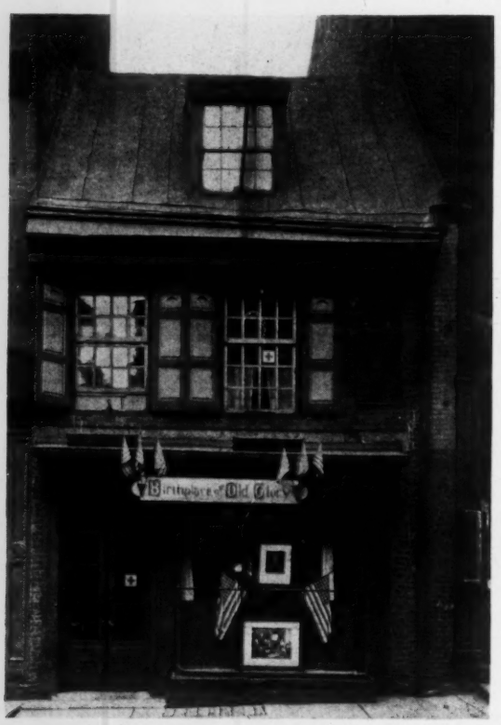
The city has many imposing business buildings, hotels, hospitals and educational institutions as well as a large manufacturing district, which has often been termed the "World's Greatest Workshop." The city boasts of the justly famous Fairmount Park and has recently completed some fine parkways and boulevards through the heart of the city. The most noted of these is the Parkway, which is lined with fine structures such as the Public Library, the Rodin Museum and at the end is the Art Gallery, which is said to have no equal, outside of Paris.

Philadelphia is primarily a city of homes, and nearby are some of the world's most beautiful suburban homes.

Some glimpses of Philadelphia are given in a booklet issued by the Chamber of Commerce, copy of which will come to every member. In it will be described points of general interest, points of historic importance, the educational and art buildings, hotels, clubs, theatres, department stores and industrial buildings.

The Philadelphia Chapter Committee has arranged its program so that an opportunity will be given to visit places of particular interest and an especially attractive program of events has been arranged for the visiting ladies.

Tea will be served every afternoon at 4 o'clock, at the Benjamin Franklin Hotel. Theatre parties have been arranged for,



AT NO. 239 ARCH STREET STANDS THE BETSY ROSS HOUSE

Get a Certificate When Buying Railroad Ticket

1. Tickets at the regular one-way tariff fares for the going journey may be obtained as early as January 19, depending upon the distance from Philadelphia. Be sure that when purchasing going ticket you request a CERTIFICATE. *Do not make the mistake of asking for a "Receipt."*

2. Present yourself at the railroad station for tickets and certificates at least 30 minutes before departure of train on which you will begin your journey.

3. *Certificates are not kept at all stations.* If you inquire at your home station, you can ascertain whether certificates and through tickets can be obtained to place of meeting. If not obtainable at your home station, the agent will inform you at what station they can be obtained. You can in such case purchase a local ticket to the station which has certificates in stock, where you can purchase a through ticket and at the same time ask for and obtain a certificate to place of meeting.

4. Immediately on your arrival at the meeting present your certificate to the endorsing officer, A. V. Hutchison, *Secretary,* as the reduced fares for the return journey will not apply unless you are properly identified as provided for by the certificates.

5. It has been arranged that the Special Agent of the carriers will be in attendance, to validate certificates. If you arrive at the meeting and leave for home again prior to the Special Agent's arrival, or if you arrive at the meeting after the Special Agent has left, you cannot have your certificate validated and consequently you will not obtain the benefit of the reduction on the home journey.

6. So as to prevent disappointment, it must be understood that the reduction of the return journey is not guaranteed, but *is contingent on an attendance of not less than* 150 *members of the organization at the meeting and dependent members of their families,* holding regularly issued certificates obtained from Ticket Agents at Starting points, from which the regular one-way adult tariff fares to place of meeting are not less than 67 cents on going journey.

7. If the necessary minimum of 150 certificates are presented to the Special Agent, and your certificate is duly validated, you will be entitled, up to and including February 4, to a return ticket *via* the same route over which you made the going journey *at one-half of the regular one-way tariff fare* from the place of meeting to the point at which your certificate was issued.

8. Return tickets issued at the reduced fares will not be good on any limited train on which such reduced fare transportation is ordinarily not honored.

9. *No refund of fare will be made on account of failure to obtain proper certificate when purchasing going tickets, nor on account of failure to present validated certificate when purchasing return tickets.*

WILLIAM PENN'S HOUSE, ORIGINALLY LOCATED IN THE OLD CITY, IS NOW IN FAIRMOUNT PARK

special luncheons at the Benjamin Franklin Hotel are listed, as well as a visit to Valley Forge, a breakfast-bridge, and a shopping tour.

Arrangements for the reception and entertainment of the visitors have been carefully worked out by the Philadelphia Chapter Committee, and the Philadelphia members will be on hand on Monday, January 27, to greet those arriving from other cities.

Registration will be handled in the Benjamin Franklin Hotel, where badges and programs will be provided, as well as advance copies of meeting papers.

The technical sessions of the meeting will be held each morning at the hotel and each afternoon at the Commercial Museum. The complete program appears on the following page.

The banquet committee plans to send advance reservation cards and a blueprint of the banquet hall so that tables can be selected and places reserved before arrival in Philadelphia.

Plans have been made to entertain the largest meeting ever held by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the Philadelphia members are anxious to make this gathering the best of the 36 annual meetings.

GENERAL CHAIRMAN
R. C. Bolsinger

HONORARY CHAIRMAN
John D. Cassell

FINANCE CHAIRMAN
Lee Nusbaum

LADIES' ENTERTAINMENT CHAIRMAN
M. C. Gillett

BANQUET CHAIRMAN
A. J. Nesbitt

PUBLICITY AND TRANSPORTATION CHAIRMAN
F. D. Mensing

HOSTESSES

Mrs. Thornton Lewis
Mrs. M. C. Gillett
Mrs. W. G. Culbert
Mrs. M. F. Blankin
Mrs. R. C. Bolsinger
Mrs. Chas. G. Binder
Miss Edgar
Mrs. A. H. McDade
Miss Theodora Jellett
Mrs. William Miller
Mrs. A. J. Nesbitt
Mrs. Lee Nusbaum
Mrs. H. J. Walther
Mrs. Warren Webster Jr.

Program for the 36th Annual Meeting

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Benjamin Franklin Hotel, Philadelphia

Monday, January 27th

10:30 a.m. Reception of Guests and Registration—Benjamin Franklin Hotel.

Time set aside for visitors to accept invitation of the heating and ventilating manufacturers of Philadelphia and vicinity to inspect manufacturing processes and plants.

2:30 p.m. Council Meeting.

4:00 p.m. Ladies' Tea.

6:00 p.m. Ladies' Dinner.

8:00 p.m. Heating and Ventilating Exposition, Commercial Museum.

9:00 p.m. Theater Party for Ladies.

11:30 p.m. Buffet Supper.

Tuesday, January 28th, 9:00 a. m.
Benjamin Franklin Hotel

9:00 a.m. Reception and Registration.

9:30 a.m. Greeting by John Cassell, Honorary Chairman.

Response by Pres. Thornton Lewis.

Introduction by R. C. Bolsinger, General Chairman.

Report of Tellers.

Power from Process and Space Heating Steam, L. A. Harding.

Report of Council.

Report of Committee on Increase in Membership, C. W. Farrar.

12:00 p.m. Ladies' Luncheon.

12:30 p.m. Luncheon for Society Officers and Authors of Papers.

1:30 p.m. Motorbus to Valley Forge for Ladies.

Tuesday, January 28th, 2:00 p. m.
Commercial Museum

2:00 p.m. Report of Finance Committee (W. T. Jones).

Pressure Difference Across Windows in Relation to Wind Velocity, by J. E. Emswiler and W. C. Randall.

Air Infiltration Through Various Types of Brick Wall Construction, by G. L. Larson, D. W. Nelson and C. Braatz.

6:30 p.m. Dinner Meeting Committee on Research—Benjamin Franklin Hotel.

8:00 p.m. Heating and Ventilating Exposition for Members and Ladies, Commercial Museum.

Wednesday, January 29th, 9:30 a. m.
Benjamin Franklin Hotel

9:30 a.m. Report of the Committee on Research.

Report of Research Director.

Surface Transmission Coefficients by Rowley, Algren and Blackshaw.

Absorption of Solar Radiation in Its Relation to the Temperature, Color, Angle and other Characteristics of the Absorbing Surface, by F. C. Houghten and Carl Gutberlet.

Preventing Condensation on Interior Building Surfaces, by Paul D. Close.

12:30 p.m. Ladies' Luncheon at the Benjamin Franklin Hotel.

2:00 p.m. Ladies' Matinee.

Wednesday, January 29th, 2:00 p. m.
Commercial Museum

2:00 p.m. Code for Testing and Rating Unit Heaters.

Method of Testing Unit Heaters Suitable for Field Use, by L. S. O'Bannon.

Measurement of the Flow of Air Through Registers and Grilles, by Prof. L. E. Davies.

4:00 p.m. Ladies' Tea—Benjamin Franklin Hotel.

6:30 p.m. Past Presidents' Dinner.

Dinner for Wives of Past Presidents.

8:00 p.m. Heating and Ventilating Show—Commercial Museum.

Thursday, January 30th, 9:30 a. m.
Benjamin Franklin Hotel

9:30 a.m. Report of Continuing Committee on the Rating and Testing of Low Pressure Steam Heating Boilers.

The Rating of Heating Boilers by Their Physical Characteristics, by C. E. Bronson.

Report of Committee on Garage Ventilation.

Report of Committee on Natural Ventilation.

Some Studies of Airation of Garages by W. C. Randall and L. W. Leonhard.

11:30 a.m. Breakfast-Bridge for Ladies — Benjamin Franklin Hotel.

Thursday, January 30th, 2:00 p. m.
Commercial Museum

2:00 p.m. Report of Guide Publication Committee.

Pipe Sizes for Hot Water Heating Systems, by Elmer Smith.

Panel Warming, by L. J. Fowler.

Development of a Method for Heat Regulation, by F. I. Raymond and R. D. Lambert.

4:00 p.m. Ladies' Tea—Benjamin Franklin Hotel.

7:00 p.m. Annual Banquet and Dance — Benjamin Franklin Hotel.

Friday, January 31st, 9:30 a. m.
Benjamin Franklin Hotel

9:30 a.m. Amendments to By-Laws.

Installation of Officers.

Friction Losses and Observed Static Pressures in a Domestic Fan Furnace Heating System, by A. C. Willard and A. P. Kratz.

Air Conditioning the Halls of Congress, by L. L. Lewis and A. E. Stacey.

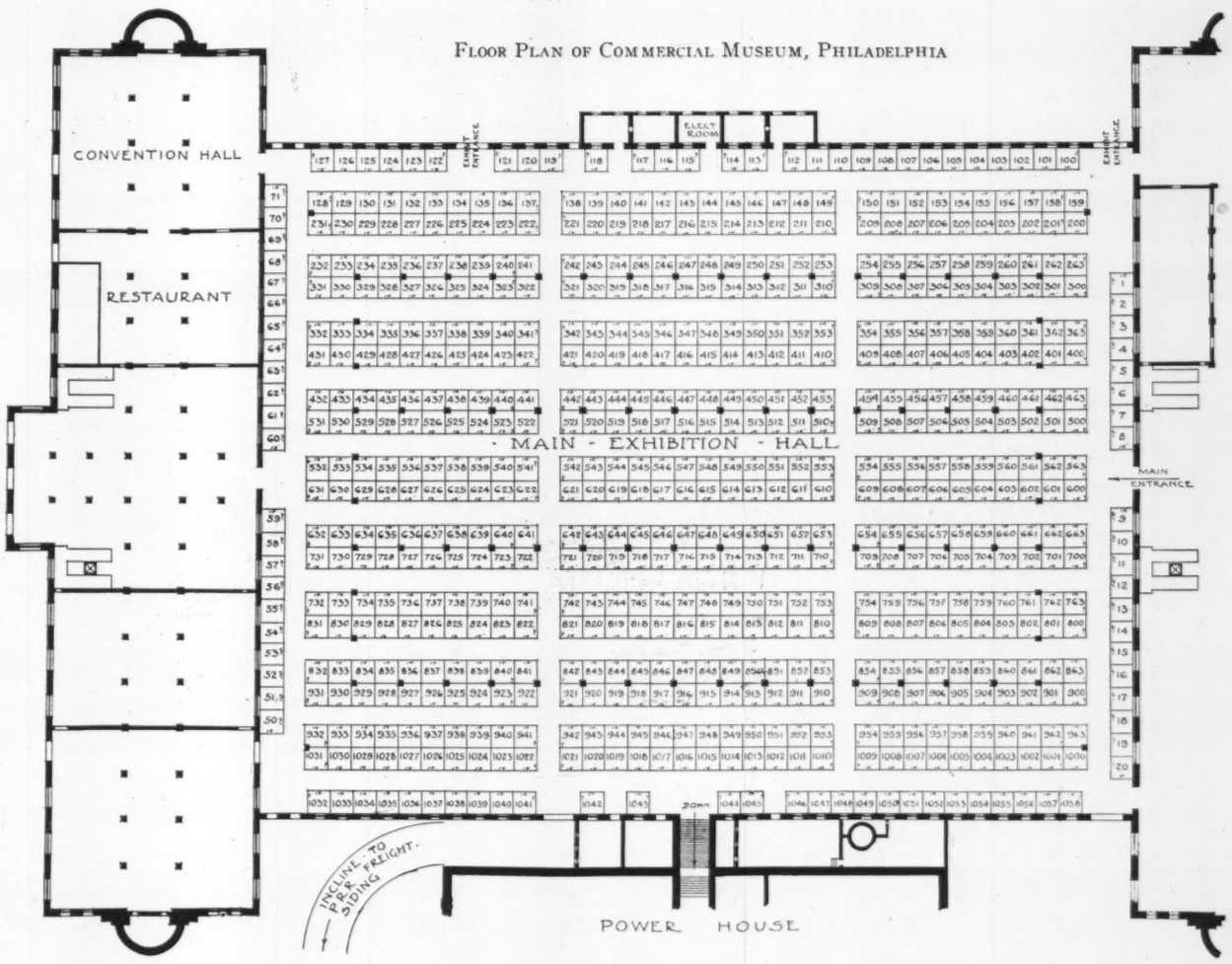
Tests of Disc and Propeller Fans, by A. I. Brown.

Resolutions.

Shopping Tour for Ladies.

Friday, January 31st, 9:30 a. m.
Benjamin Franklin Hotel

1:30 p.m. Council Meeting.



Ready for the Exposition

FINAL preparations for the first International Heating and Ventilating Exposition to be held at the Commercial Museum, Philadelphia, Pa., January 27 to 31, indicate that the most extensive display of modern equipment ever gathered under one roof will be seen by thousands of people in Philadelphia and vicinity, as well as the members and guests of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS who will attend this exposition.

On the accompanying list will be found the names of leading manufacturers of equipment; they will come from all parts of the country to demonstrate the newest appliances to maintain effective heating and adequate ventilation in every type of building.

Admission to the Exposition for members of the Society is by means of their registration badge. Guests of manufacturers will be admitted by special ticket. The Museum is located at 34th St. near Spruce, and may be reached by bus or street car. Special bus service from the Benjamin Franklin Hotel to the Exposition has been arranged, so that transportation will be comfortable and rapid.

Special arrangements have been made for members and ladies attending the A. S. H. V. E. Meeting to officially inspect the exhibits on Tuesday evening, January 28. The program of the meeting also provides that the convention hall of the Commercial Museum be the scene of the afternoon sessions on Tuesday, Wednesday and Thursday.

The Society will have Booths 7 and 8 at the entrance to the Exposition where information about Society activities will be available. The Research Laboratory will have an extensive exhibit and will demonstrate the work being done at the Pittsburgh station and will also have adequate space to show some of the investigations carried on at the co-operating college laboratories. These Booths Nos. 128 to 136 are conveniently located at the entrance of the convention hall where the technical sessions will be held and in that way visitors will have an opportunity to get an intimate view of the various research investigations being conducted by the Society and under its auspices.

In addition to the exhibit of modern equipment there will also be a section devoted to ancient methods of heating and ventilating. Various manufacturers have loaned exhibits from their museums so that anyone who visits the exposition can get a picture of the old and the new side by side.

The Government bureaus are co-operating and the Bureau of Standards has arranged to show methods of measuring thermal conductivity.

With all of the work that has been done the industry is looking forward with great pleasure to this unusually fine Exposition which is in prospect for the week of January 27.

People will travel from all parts of the country and from some foreign countries to witness this International Exposition. In addition to the technical men who will be present, public interest has been aroused in the exhibit of this industry which

means so much in comfort and health to organized society.

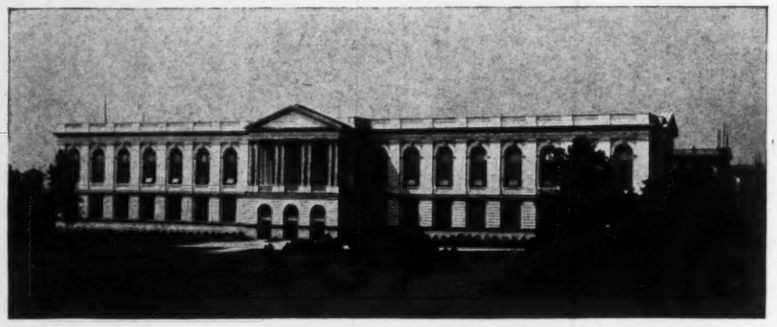
For the convenience of the reader a list of exhibitors is appended and the location in the exhibit hall may be readily found by consulting the floor plan.

Advisory Committee for A.S.H.V.E.

H. P. Gant, *Chairman,* York Heating & Ventilating Corp.
A. S. Armagnac, Heating and Ventilating.
D. S. Boyden, Edison Electric Illuminating Co. of Boston.
W. H. Carrier, Carrier Engineering Corp.
A. C. Edgar, Certified Heating Association, Inc.
Roswell Farnham, Buffalo Forge Co.
C. V. Haynes, Hoffman Specialty Co.
E. B. Langenberg, Langenberg Mfg. Co.
J. I. Lyle, Carrier Engineering Corp.
J. F. McIntire, United States Radiator Corp.
H. C. Murphy, Reed Air Filter Co.
F. R. Still, American Blower Co.
E. K. Webster, Warren Webster Co.
H. L. Whitelaw, American Gas Products Co.

Co-Operating Committee

O. H. Fogg, Pres. American Gas Association.
C. H. Hammond, Pres. American Institute of Architects.
E. M. Fleischmann, Pres. American Oil Burner Association.
A. J. Wood, Pres. American Society of Refrigerating Engigineers.
Walter Klie, Pres. Heating & Piping Contractors Natl. Assn.
H. T. Richardson, Pres. National Boiler & Radiator Mfg. Assn.
John W. Meyer, Pres. National District Heating Association.
W. C. Hanson, Pres. National Pipe & Supplies Association.
C. E. Hall, Director, National Warm Air Heating Association.



COMMERCIAL MUSEUM OF PHILADELPHIA

Booth No.	Name of Exhibitor	Address
115	ABC Oil Burner Sales Corp.,	802 N. Broad St., Philadelphia, Pa.
508-509	Aerologist, The,	121 N. Clark St., Chicago, Ill.
615	Aerovent Ventilating Co.,	4052 Ridge Ave., Philadelphia, Pa.
19-20	Air Control Corp. of New York,	500 E. 20th St., New York
721	Airite Corp.,	50 Church St., New York
603-604	Air Reduction Sales Co.,	342 Madison Ave., New York
519	Airmaster Corp.,	162 W. Austin St., Chicago, Ill.
856-857	Air-Way Elec. Appl. Corp.,	Toledo, Ohio
701	Alexander Bros., Inc.,	14 South St., Philadelphia, Pa.
519	Allen Air Turbine Ventilator Co.,	14th and Howard St., Detroit, Mich.
5-6	American Brass Co.,	Waterbury, Conn.
942-943	American District Steam Co.,	No. Tonawanda, N. Y.
158-159-200-201	American Gas Association,	420 Lexington Ave., N. Y.
100-101	American Gas Products Corp.,	376 Lafayette St., New York
450	American Metal Products Corp.,	1228 Locust St., Philadelphia, Pa. (Main Office, St. Louis, Mo.)
351-352-353-410-411-412	American Radiator Co.,	40 West 40th St., New York
249-250	American Safety Boiler Control,	Port Chester, N. Y.
7-8	American Society Heating & Ventilating Engineers,	29 West 39th St., New York
	American Oil Burner Assn.,	342 Madison Ave., New York
507	American Temp. Indicating Co.,	Toledo, Ohio
507	American Warming & Vent. Co.,	1017 Summit St., Toledo, Ohio
358	Ames Iron Works,	Oswego, N. Y.
362-363-400-401	Ames Pump Co., Inc.,	30 Church St., New York
954	Anthracite Coal Service,	1421 Chestnut St., Philadelphia, Pa.
705	Armstrong Mch. Works,	Three Rivers, Mich.
249-250	Austin Heat Transference Corp.,	6 Broad St., Portchester, N. Y.
115-116	Automatic Burner Corp.,	312 N. May St., Chicago, Ill.
1021	Automatic Elec. Steam Corp.,	1 East 42nd St., New York
260	B-Line Boiler Co.,	E. 131 St. and Taft Ave., Cleveland, Ohio
502-503	Barnes & Jones,	128 Brookside Ave., Boston, Mass.
106	Bear Engineering & Const. Co.,	1518 Summer St., Philadelphia, Pa.
648	Beckwith Co., The,	Dowagiac, Mich.
653-710-711	Bishop & Babcock Sales Co.,	4901 Hamilton Ave., N.E., Cleveland
810-811	Bristol Co., The,	Waterbury, Conn.
342-343	Brown Instrument Co.,	Philadelphia, Pa.
1053-1054	Brownell Co.,	Dayton, Ohio
620-621	Bryan Steam Corp.,	Peru, Ind.
208-209	Bryant Heater & Mfg. Co.,	17825 St. Clair Ave., Cleveland, Ohio
357	Builders Iron Foundry,	9 Codding St., Providence, R. I.
445	Burnham Boiler Corp.,	Irvington, N. Y.
450	Building Equipment Co., Inc.,	1228 Locust St., Philadelphia, Pa.

Booth No.	Name of Exhibitor	Address
558	Cashing, W. D., Co.,	35 Hartford St., Boston, Mass.
1-2-3-4	Carrier Engineering Corp.,	850 Frelinghuysen Ave., Newark, N. J.
451-452	Celotex Co., The,	919 N. Michigan Ave., Chicago, Ill.
346	Century Electric Co.,	1806 Pine St., St. Louis, Mo.
140	Century Engineering Corp.,	Cedar Rapids, Iowa
519	Champion Sales Co.,	102 N. 5th St., Philadelphia, Pa.
655-656-657	Chicago Pump Company,	2336 Wolfram St., Chicago, Ill.
1055-1056	Clayton, W. L., Inc.,	901 Bergen Ave., Jersey City, N. J.
154	Clow Gasteam Heating Co.,	Delaware Ave. and South St., Philadelphia, Pa.
341 and 422	Cochrane Corp.,	17th St. bel. Allegheny Ave., Philadelphia, Pa.
104	Columbia Burner Co.,	Toledo, Ohio
221	Combustion Fuel Oil Burner Co.,	Milwaukee, Wis.
453	Condon, James A., Inc.,	3rd and Arch Sts., Philadelphia, Pa.
321	Cook Electric Co.,	2700 Southport Ave., Chicago, Ill.
462-463	Cooling & Air Conditioning Corp.,	11 W. 42nd St., New York
421	Copper Radiator Sales Corp.,	Imperial Bldg., Schenectady, N. Y.
506	Coppus Engineering Corp.,	344 Park Ave., Worcester, Mass.
550	Cox Co., Abram,	American and Dauphin Sts., Philadelphia, Pa.
404-405-406-407	Crane Company,	836 S. Michigan Ave., Chicago, Ill.
801-802	Crain Pump & Lumber Co.,	17 N. 7th St., Philadelphia, Pa.
122	Crystal Oil Burner Corp.,	1440 Broadway, New York
602	Culbert-Whitby Company,	2019 Rittenhouse St., Philadelphia, Pa.
109-110	Direct Control Valve Co.,	332 S. Michigan Ave., Chicago, Ill.
607	Domestic Engineering,	1900 Prairie Ave., Chicago
1057-1058	Domestic Stoker Co.,	7 Dey St., New York
546	Draft-A-Justor Corp.,	228 N. La Salle St., Chicago, Ill.
257	Duo-Tor Mfg. Co.,	Dayton, Ohio
554-555-608-609	Dunham, C. A., Co.,	450 E. Ohio St., Chicago, Ill.
402	Durston Gear Corp.,	Syracuse, N. Y.
805	Eagan, Walter H., & Co.,	1612 Vine St., Philadelphia, Pa.
854-855	Economy Piping Mchy. Co.,	3431 W. 48th St., Chicago, Ill.
137	Economy Oil Burner Co.,	26 Aberdeen St., Harrisburg, Pa.
502	Elliott Edwin, & Co.,	560 No. 16th St., Philadelphia, Pa.
902	Emerson Elec. Mfg. Co.,	2018 Washington Ave., St. Louis, Mo.
408	Ever Hot Heater Co.,	5241 Wesson Ave., Detroit, Mich.
511	Faries, Gilbert S.,	21 Transportation Bldg., Philadelphia, Pa.
320-319	Fitzgibbon Boiler Co., Inc.,	570 Seventh Ave., New York
702-703	Flagg, Stanley G., Co., Inc.,	1481 Chestnut St., Philadelphia, Pa.
549	Foxboro Co.,	Neponset Ave., Foxboro, Mass.
123	Fowler Oil Burner Co.,	19 Union St., Worcester, Mass.
700	Frank, O. E., Heater & Engr. Co.,	20 Milburn St., Buffalo, N. Y.
313-314	Fuel Oil & Temperature Jnl.,	420 Madison Ave., New York
302	Fulton Sylphon Co. (Sheffler Cross Co., Inc.),	Drexel Bldg., Philadelphia, Pa.

Booth No.	Name of Exhibitor Address
544-545-618-619	General Electric Co., 1 River Rd., Schenectady, N. Y.
206-207	General Gas Light Co., 44 W. Broadway, New York
557-558-605-606	Grinnell Company, Inc., Providence, R. I.
106	General Iron Works, Cincinnati, Ohio
645	Germer Stove Co., Erie, Pa.
1050-1051	Haines, William S., & Co., Cor. 12th and Buttonwood St., Philadelphia, Pa.
149	Hardinge Bros., Inc., 4149 Ravenswood Ave., Chicago, Ill.
602	Hart & Crouse Co., Utica, N. Y.
759	Hart & Hutchinson Co., Corbin Ave., New Britain, Conn.
511-512	Hartzell Propeller Co., 26 S. 15th St., Philadelphia, Pa.
119	Heating Journals, Inc., 167 Madison Ave., New York
559	Heating, Piping and Air Conditioning, 1900 Prairie Ave., Chicago
9-10	Heating & Ventilating Magazine, 521 5th Ave., New York
542-543	Heggie-Simplex Boiler Co., Joliet, Ill.
741	Heilman Boiler Works, Allentown, Pa.
322	Heintz Mfg. Co., 1332 Arch St., Philadelphia, Pa.
508	Hill, E. Vernon, Co., 121 N. Clark St., Chicago, Ill.
513-514	Hirschmann, W. F., Co., 220 Delaware Ave., Buffalo, N. Y.
906-907-908-909	Hoffman Specialty Co., Inc., Waterbury, Conn.
206	Humphrey Radiant Fire Mantel (Gen. Gaslt. Co.), Kalamazoo, Mich.
15-16	Illinois Engineering Co., 21st St. and Racine Ave., Chicago, Ill.
453	International Boiler Works Co., East Stroudsburg, Pa.
117	International Burners Corp., 225 W. 34th St., New York
310	International Heating Co., 3808 Park Ave., St. Louis, Mo.
309	Iona Ventilator Co., Inc., 2821 W. Dauphin St., Philadelphia, Pa.
242	Janette Mfg. Co., 556 W. Monroe St., Chicago, Ill.
17-18	Johnson Service Co., 28 E. 29th St., New York (Main Office, Milwaukee, Wis.)
252-253	Johnson, S. T., & Co., 311 N. 20th St., Philadelphia, Pa.
127	Jones Hollow Ware Co., Baltimore, Md.
551	Kelly Brass Works, 226 W. Ontario St., Chicago, Ill.
750	Kelsey Heating Co., Syracuse, N. Y.
413-414	Kewanee Boiler Corp., Kewanee, Ill.
243-244	Kewanee Boiler Co., Inc., 570 Seventh Ave., New York
962	Kieley & Mueller, Inc., 34 W. 14th St., New York
963	Korfund Co., Inc., 235 E. 42nd St., New York
147-148	Kunkel Heating Service, Inc., 1733 Sansom St., Philadelphia, Pa.
652	Langenberg Mfg. Co., 4519 Euclid Ave., St. Louis, Mo.
1052	Leader Boiler & Heater Co., 310 S. Michigan Ave., Chicago, Ill.
654	Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.
741	Lehigh Fan & Blower Co., Allentown, Pa.
505	Leslie Co., Lyndhurst, N. J.
257	Lewis & Company, 709 Arch St., Philadelphia, Pa.
612-613	Linde Air Products Co., 205 E. 42nd St., New York
304	Liquidometer Corp., Skillman Ave. and 37th St., Long Island City, N. Y.
653	Massachusetts Blower Co., Cleveland, Ohio
356	McCord Radiator & Mfg. Co., 2587 E. Grand Blvd., Detroit, Mich.
706	McDonell & Miller, Wrigley Bldg., Chicago, Ill.
120-121	McIlvaine Burner Corp., 749 Custer Ave., Evanston, Ill.
458-459	McQuay Radiator Corp., 35 E. Wacker Drive, Chicago, Ill.
315-316	Marr Oil Heat. Mch. Corp., 704 Fox Bldg., 1612 Market St., Philadelphia, Pa.
560-561	Marsh, Jas. P., & Co., 2073 Southport Ave., Chicago, Ill.
113-114	May Oil Burner Corp., Baltimore, Md.
202	Mears-Kane-Ofeldt, Inc., 1903 E. Hagert St., Philadelphia, Pa.
541 and 622	Mercoid Corp., 25 Church St., New York
644	Meyer Furnace Co., Peoria, Ill.
1009	Midwest Mfg. Co., Bradford, Pa.
221	Milwaukee Air Pump Co., Milwaukee, Wis.
842	Mineral Felt Insulating Co., 2284 Albion St., Toledo, Ohio
454-455	Minneapolis-Honeywell Reg. Co., 2747 4th Ave., S., Minneapolis, Minn.
910-911	Modine Mfg. Co., Racine, Wis.
863 and 900	Molby Boiler Co., Inc., 420 Lexington Ave., New York
762	Monarch Metal Weatherstrip Co., 5020 Penrose St., St. Louis, Mo
1048-1049	Motorstoker Corp., 250 Park Ave., New York
210-211	Motor Wheel Corp., Lansing, Mich.
105	Mueller, L. J., Furnace Co., 167 Reed St., Milwaukee, Wis.
661	Multicell Radiator Corp., 80 Terrace, Buffalo, N. Y.
500-501-562-563-600-601-662-663	Nash Engineering Co., South Norwalk, Conn.
254-255-256	National Radiator Corp., 52 W. 42nd St., New York
753	National Regulator Co., 196 Lexington Ave., New York (Chicago Office, 2301 Knox Ave.)
647	National Warm Air Heating Assn., Care of Allen W. Williams, Man. Dir., 174 E. Long St., Columbus, Ohio
11-12	Nesbitt, John J., Inc., State Road and Rhawn St., Holmesburg Jct., Philadelphia, Pa.
641	Newport Boiler Co., 529 S. Franklin St., Chicago, Ill.
111	National Airoil Burner Co., Philadelphia, Pa.
956	National Air Filter Co., 205 Central Ave., Louisville, Ky.
1000-1001	O E Specialty Mfg. Co., Milwaukee, Wis.
119	Oil Heat, 167 Madison Ave., New York
355	Orr & Sembower, Inc., Reading, Pa.
921	Parks-Cramer Co., Fitchburg, Mass.
548	Penn Electric Switch Co., Des Moines, Iowa
707-708	Peerless Unit Ventilation Co., Bridgeport, Conn.
259	Pennsylvania Furnace & Iron Co., Warren, Pa.
922	Phillips Drill Co., 1537 Cortland St., Chicago, Ill.
359-360-361	Pierce-Butler & Pierce Mfg. Co., 41 E. 42nd St., New York
615-616	Piqua Electric Mfg. Co., Piqua, Ohio
203	Pittsburg Water Heater Co., Pittsburgh, Pa.
661	Power Efficiency Corp., 137 Arthur St., Buffalo, N. Y.
128 to 136	Research Laboratory—Am. Soc. Heating & Vent. Engineers, 4800 Forbes St., Pittsburgh, Pa.
222	Rawlplug Co., Inc., 66 W. Broadway, N. Y.
350	Raymond, F. I., Co., 328 N. La Salle St., Chicago, Ill.
642-643	Richardson & Boynton Co., 260 5th Ave., New York
262-263	Richmond Radiator Co., 1480 Broadway, New York
953	Ric-Wil Company, 1562 Union Trust Bldg., Cleveland, Ohio
704	Robertson, H. H., Co., Grant Bldg., Pittsburgh, Pa.
1006-1007-1008	Rome Brass Radiator Corp., 1 E. 42nd St., New York
756	Rome-Turney Radiator Co., Rome, N. Y.
150-151	Roper, Geo. D., Corp., 707 S. Main St., Rockford, Ill.
1021	Ross Safety Switch Corp., 1 E. 42nd St., New York
157	Ruud Mfg. Co., 274 Madison Ave., New York
961	Reed Air Filter Co., 215 Central Ave., Louisville, Ky.
763 and 800	Sarco Co., Inc., 183 Madison Ave., New York
442	Schade Valve Mfg. Co., 2527 N. Bodine St., Philadelphia, Pa.
354	Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia, Pa.
617	Sheer, H. M., Co., Quincy, Ill.
303	Sheffler-Gross Co., Inc., Drexel Bldg., Philadelphia, Pa.
125-126	Silent Automatic Corp., 255 Maldrum Ave., Detroit, Mich.
118	Silent Glow Oil Burner Corp., 1000 Park St., Hartford, Conn.
757-758	Skidmore Corp., 1535 Dayton St., Chicago, Ill.
520	Skinner Bros. Mfg. Co., 1474 S. Vandeventer Ave., St. Louis, Mo.
403	Smith Twin Tubular Boiler Co., 1111 Frankford Ave., Philadelphia, Pa.
300-301	Spencer Heater Co., 609 Otis Bldg., Philadelphia, Pa.
258	Sprayo-Flake Co., 56 S. May St., Milwaukee, Wis.
547	Star Expansion Bolt Co., 147 Cedar St., New York
516	Stat-Amatic Inst. & Appl. Co., 1703 Park St., Hartford, Conn.
760-761	Staynew Filter Corp., Rochester, N. Y.
261	Steinhurst, Emil, & Sons, Inc., Utica, N. Y.
912	Sterling Engineering Co., Milwaukee, Wis.
955	Sterling Engr. & Mfg. Corp., Hyde Park, Boston, Mass.
443	Stickle Steam Specialties, Co., Indianapolis, Ind.
752	Strandwitz & Scott, Inc., 537 S. Second St., Camden, N. J.
102-103	Sweet & Doyle Fdry. & Mch. Co., Troy, N. Y.
456-457	Taco Heaters, Inc., 342 Madison Ave., New York
709	Tallmadge, Webster & Co., Inc., 50 Church St., New York
251	Teesdale Mfg. Co., 427 Market St., Grand Rapids, Mich.
108	Texo Sales Co., Inc., 241 Walnut St., Cincinnati, Ohio
441 and 522	Thatcher Co., 39-41 Francis St., Newark, N. J.
916-917	Thermal Units Co., Union Stock Yards, Chicago, Ill.
307	Thrush, H. A., & Co., Peru, Ind.
415-416	Time-O-Stat Control Co., Elkhart, Ind.
409	Trerice, H. O., Co., 1338 W. Lafayette Blvd., Detroit.
612	Union Carbide Co., 205 E. 42nd St., New York
845-846	U. S. Bureau of Standards, Washington, D. C., L. J. Briggs, Act. Dir.
556	U. S. Gypsum Co., 300 W. Adams St., Chicago, Ill.
658-659-660	U. S. Radiator Corp., 1st Nat. Bk. Bldg., Detroit, Mich.
852-853	Vinco Co., Inc., 75 Vesey St., New York
754-755-808-809	Warren Webster & Co., Camden, N. J.
1010	Weidemann Mch. Co., 1815 Sedgley Ave., Philadelphia, Pa.
742-743-820-821	Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
347-348-349	Weil-McLain Co., Michigan City, Ind., Chicago Office 641 W. Lake St.
801-802	Westco-Chippewa Pump Co., 90 West St., New York
748-749	Wickes Boiler Co., Saginaw, Mich.
1042	Wilcolator Co., 17-23 Nevada St., Newark, N. J.

Booth No.	Name of Exhibitor	Address
1043	Wilson Bros.,	34 S. 17th St., Philadelphia, Pa.
806-807	Winchester Repeating Arms Co.,	New Haven, Conn.
138-139	Winslow Boiler & Engr. Co.,	844 Rush St., Chicago, Ill.
812-813	Wolverine Tube Co.,	1411 Central Ave., Detroit, Mich.
521	Wood Conversion Co.,	101 Park Ave., New York
504	Wright Austin Co.,	315 W. Woodbridge St., Detroit, Mich.
805	Weil Pump Co.,	215 W. Superior St., Chicago, Ill.
460-461	Whittington, W. P., Inc.,	Indianapolis, Ind.
305	Wing, L. J., Mfg. Co.,	154 W. 14th St., New York
940-941-1022-1023	Yale & Towne Mfg. Co.,	Stamford, Conn.
552-553-610-611	York Heating & Ventilating Corp.,	1541 Samson St., Philadelphia, Pa.
862	Young Radiator Co.,	Racine, Wis.
511	Ziegler, M. P., & Co.,	124 S. Fountain Ave., Springfield, Ohio

Death of Edward Grassler

Word has just been received of the death of Edmund Grassler at his home, 214 Third St., Milwaukee, Wis., on Sunday, October 27, and at the November meeting of the Wisconsin Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS appropriate action on the passing of their fellow member was taken by the members present.

Mr. Grassler was born in Milwaukee, February 29, 1860, and except for a brief period spent in St. Louis his entire life was spent in Milwaukee, and his entire business life was devoted to the heating, plumbing and lighting fields.

He was very active in association, fraternal and social organizations, and had a host of friends in the local, state and national organizations to which he belonged.

Mr. Grassler was educated in the schools of Milwaukee and spent 45 years in the contracting business in that city, and at the time of his death he was a member of the firm of Grassler and Gezelschap.

Mr. Grassler joined the Society in 1919 and was among the organizers of the Wisconsin Chapter. He was also a member of the *Milwaukee Heating Contractors Association, Master Plumbers Association, Builders Association,* the Wisconsin Club, the Knights of Pythias and the Elks.

Mr. Grassler was a regular attendant at Society conventions and was also prominent in the activities of the *Heating and Piping Contractors National Association* which he served as president.

Surviving Mr. Grassler are his widow, a son and daughter, to whom the Officers and Council of the Society extend their sincere sympathy for the loss that they have suffered.

Death of August Kastello

Word has been received of the death of August Kastello of Montreal, who was born August 1, 1877, in Berlin, Germany, and graduated from Berlin University with a B. S. degree.

Mr. Kastello's work was chiefly in power house heating and ventilating and similar mechanical work. For a number of years he was construction engineer for the Hanover Portland Cement Company, and served as chief power plant engineer for G. I. R. System.

Several years of his professional career were spent in government service as mechanical superintendent of mechanical construction and operation for the British Chemical Company of Trenton, Ontario.

For a number of years he was branch manager in the Montreal office of the C. A. Dunham Co.

Mr. Kastello's death will come as a shock to the engineers with whom he was associated, and the Officers and Council extend their sincere sympathy to his family who survive.

Report on Powdered Coal

A report entitled "Temperatures for Rapid Self-Heating of Powdered Coal and the Semicoke made Therefrom" by F. A. Hartgen and D. F. Smith, has recently been issued by the Bureau of Mines of the Department of Commerce.

This is Report No. 2960 and describes the apparatus and methods used, and also discusses experimental results as shown in heating curves and curves of densities and mechanical analyses of different screen sizes of powdered coal and semicoke.

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the Journal of the Society at least twice during every year, preferably just prior to each meeting:

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features, and the sale of tickets for group features be discouraged.

6—That the raising of Funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter, or local members, be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

Local Chapter Reports

Kansas City

November 12, 1929: The November meeting of the Kansas City Chapter of the Society was held at the Ambassador Hotel, November 12, with an attendance of 24 members and guests, with Pres. Carl Clegg presiding.

After the regular order of business had been attended to, it was proposed and seconded that a letter be written to Ben Naylor, extending the sympathy of the Chapter to him on account of his long illness.

The first topic of the evening, Central Steam Heating, was presented by David Caleb and J. M. Arthur, both of Kansas City. Mr. Arthur commented particularly concerning the general application of central station heating in Kansas City, its advantages and benefits to the city at large.

Mr. Caleb followed with an interesting description of the distribution of high pressure steam from Grand Avenue to substations and thence to the various buildings in the downtown section. The discussion which followed was led by H. C. Henrici, Mr. Dawson and others.

The second subject of the evening was presented by Nate W. Downes, who discussed the recently adopted boiler code or rating of output for boilers. Mr. Downes fully described the gradual evolution of the Code to its present form.

Due to the lateness of the hour the subject of unit heater testing which was scheduled for discussion was postponed until the following meeting.

Massachusetts

November 12, 1929: The regular monthly meeting of the Massachusetts Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS was held at the Boston City Club, November 12, 1929, at noon.

After the luncheon, which was attended by 40 members and guests, Leo Sherman of the Vinco Co. demonstrated by means of laboratory apparatus the effect of this boiler cleanser on a heating system.

The members of the *Heating and Piping Contractors Boston Association* and the members of the various boiler manufacturers were the guests at this meeting, which was adjourned after the usual discussion.

Illinois

December 9, 1929. The December meeting of the A. S. H. & V. E. was held on Monday, December 9, at the Hotel Sherman, with an attendance of 138 members and guests.

After the Secretary read the minutes of the November meeting, which were approved as read, Pres. H. G. Thomas introduced R. E. Moore, Bell & Gossett Co., as the newly appointed chairman of the Membership Committee.

Temperature control was the subject of discussion at the meeting, each speaker being limited to ten minutes. The first speaker was L. O. Grauer of American Radiator Co., who described mercoid controls and dual control equipment.

G. D. Kingsland, Minneapolis-Honeywell Co., covered, in his talk, the broad field of controls in addition to the conventional room thermostat. He also described some equipment for controlling unit heaters singly and by groups from return line condition and room thermostats. He also described equipment to maintain a fixed temperature in radiators.

Homer Horton, National Regulator Co., then discussed, in a general way, the importance and value of temperature control. He predicted a continuing greater willingness of people to purchase the comfort and convenience that temperature control gives and urged sane and reasonable application of the art.

A paper by F. I. Raymond explained the application of the duostat for balancing in either steam or water the rate of heat lost from the building with the rate of heat supplied to the building. He described the instrument, principle of operation, and its application.

J. R. Vernon, Johnson Service Co., then talked on the development of the dual thermostat and the dual system of temperature regulation with which he was familiar.

W. P. McFarland, Powers Regulator Co., spoke on temperature control and steam control devices in general.

The last speaker of the evening was F. L. Hutchinson, Conco Temperature Control Co., who discussed temperature control instruments and their principle of operation.

An interesting discussion followed after which the meeting was adjourned.

November 11, 1929. Sixty members and guests assembled at the Sherman Hotel, Chicago, for the regular monthly meeting of the Illinois Chapter of the Society, which was held on November 11, 1929.

The speaker of the evening, F. G. Outcalt, development engineer of Linde Air Products Co., representing the *International Acetylene Association*, gave an excellent talk on welding. Mr. Outcalt stressed the importance of correct technique, the convenience and economy of erection and the near approach to the ideal of a one piece system of piping. For determining a welder's ability, he described the simple testing of a specimen weld.

Slides showing the installation in the Carbide and Carbon Building and the new Montgomery Ward Building were shown, which among other things indicated the possibility of installing piping in extremely close quarters and the comparative ease of making changes or cutting into piping.

An interesting discussion followed in which Messrs. Small, Heckel, Loth, Weinshank, Dickerson, Johnson, Crone, Reid, Lange, Browning and Wilson asked numerous questions, and in some instances described experiences in welding practice.

After much debating the meeting was adjourned.

Michigan

November 11, 1929: One hundred and thirty-four members and guests attended the November meeting of the Michigan Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, which was held at the Cadillac Athletic Club, Detroit.

During the dinner, entertainment was provided and afterwards Pres. W. G. Boales called upon the members and guests to rise in memory of the members who lost their lives in the World War.

Following this there was a roll call and the usual report of the Secretary and the Chairman of Committees. In addition President Boales spoke of the 36th Annual Meeting which will be held in Philadelphia, January 28 to 31, and urged the members to make their plans to attend.

The meeting was devoted to a discussion of fuel and the first speaker was Charles Griffith of the Anthracite Coal Service. Mr. Griffith discussed the problems which his organization had to meet in an endeavor to increase the efficiency of the burning of anthracite coal. In the course of his talk he brought out the fact that, contrary to the opinion of some engineers, coal is not a decadent fuel, but will always be used by those who have to consider the cost of fuel.

Homer Linn, Chicago, who was then introduced, gave an interesting talk, laying great stress on the necessity of having an automatic draft regulator if maximum results are to be obtained with the average oil burning installation. He stressed the necessity of having a clean boiler, a boiler of the proper size, one which is fully accessible, an oil burner which is purchased from

a manufacturer with ample service facilities, and the use of proper fuel if best results are to be obtained.

Mr. Linn stated that in nine years experience 76 per cent of the trouble reports which have come to his office have been caused by chimneys, in that either the chimneys were not tight or were not of the proper size and height. He further brought out the fact that dirty water in the boiler causes trouble and that the improper location of the thermostat is also responsible for inefficient oil burner operation. Automatic controllers can be of prime importance to an oil burning installation and they also can give infinite trouble if not properly applied, was a point explained by Mr. Linn. He also brought out the fact that dirty oil has in some cases been the cause of complaints from oil burner users.

The next speaker was William Hampton, Detroit, who spoke on the future of gas for house heating. He stated that the users of gas heating in homes will probably always have to pay a premium and in his opinion the future of gas for house heating is with the home owner who is willing to pay a preference for the advantages to be had with gas heating.

Following Mr. Hampton's talk the meeting was thrown open for discussion and remarks were heard from Edward Harrigan concerning the relative cost of oil and anthracite coal. Answering Mr. Harrigan's discussion, Charles Griffith replied that information which he considered to be authentic showed that one ton of anthracite coal will deliver the same heat as 170 gallons of fuel oil under ordinary operating conditions.

A rising vote of thanks was given to the speakers of the evening and the meeting was adjourned.

New York

December 16, 1929. The chapter was honored by the presence of Pres. Thornton Lewis, who spoke on the activities of the Society, including the research work being conducted at the lab- also spoke of the future of the Society, and told of the appreciation of the engineers in France and Great Britain for the work being done by our organization.

Mr. Lewis discussed the membership work of Mr. Farrar and urged the chapter members to spur their efforts in order to aid their committee in obtaining the maximum number of applications possible before Jan. 15. At the time of the meeting, New York was fourth in the standing among the chapters in the number of applications obtained. The plans for the annual meeting in Philadelphia were described by Mr. Lewis, and he also told of the progress of the International Heating and Ventilating Exposition to be held in conjunction with the convention.

Mr. Werner Nygren was the guest speaker of the evening, and his talk was most enlightening and interesting. He told of the air conditioning installations in the New York Stock Exchange and Macy's Department Store, and contrasted the two, the New York Stock Exchange installation being the pioneer installation of its kind, and Macy's store being an example of a modern cooling plant. At the time the New York Stock Exchange equipment was installed in 1902, little was known of the subject of air conditioning, and the undertaking was considered an innovation.

Mr. Nygren described the difficulties encountered, first, in convincing the skeptical building committee of the exchange of the practicability of the feature, and second, in designing and installing the equipment. The Macy job was not without its difficulties, but they were of an entirely different nature. The chief obstacles were of a "geographical nature," as Mr. Nygren stated, because of the lack of space for the equipment and because of the unsatisfactory channels for the ducts.

New York members of the *American Society of Refrigerating Engineers* were invited to attend this meeting, and the total attendance was 124, a record for this year.

November 11, 1929.—At the monthly meeting of the New York Chapter, Louis T. M. Ralston, consulting engineer, described the salient features of the heating system that was designed and installed in the new Chrysler Bldg., located at the corner of 42nd Street and Lexington Avenue, New York.

This building, said to be the tallest structure in the world, is 75 stories high and 1,075 ft. from the basement to the top of the flagpole on the roof. The ground floor covers an area of 38,000 sq. ft., and the building contains a total of 13,000,000 cu. ft.

Steam for building heating, kitchens, and hot water service is obtained from the New York Steam Corporation. It enters the building at 130-lb. pressure through two 10-in. mains. All of the piping installed by the New York Steam Corporation is of welded construction which Mr. Ralston said is the first of its kind to be installed in New York City.

The high-pressure steam is first reduced to 80-lb. then to 40-lb. and finally to 5-lb. for which initial pressure the heating system has been designed.

In the building sub-basement a 6-ft. wide pipe space has been constructed between the building foundation wall and an inside wall. A branch from the low pressure main is located in this pipe space and risers carry steam up from it to radiators on the first to third floors. Other risers from this same branch feed direct radiation from the fourth to the 16th floors.

A 10-in. line carries steam at 40-lb. pressure to the 30th floor, which has been set aside for piping other mechanical equipment such as fans, hot water heaters and elevator motor generator sets.

A branch line from the medium-pressure riser delivers steam through a reducing valve to a low-pressure header in this pipe space. From this header steam is supplied for building heating through down risers to the 17th floor.

The medium-pressure riser continues 8 in. from the 30th floor to the 60th floor, where it delivers steam to another full story pipe space. A low-pressure steam header on this floor feeds steam down to the 30th floor and up to the 72nd.

The floors above the 72nd are used for observation tower purposes, and it was considered only right that the leasee of these floors should pay for the steam necessary to heat them. This necessitated extending the medium-pressure steam riser and separately metering the steam used to heat these floors.

Copper radiators of the extended surface type have been installed under all of the windows. In addition to this, radiators have been provided for all interior corridors. This was felt necessary in order to take care of the air infiltration coming from the elevator shafts, and also because the corridors are some distance from the outside of the building. In the offices the radiators are provided with metal enclosures. A total of 179,000 sq. ft. of equivalent direct radiation has been provided. In addition to this 44,000 sq. ft. of hot-blast radiation has been installed for heating the entrance and basement floors.

In calculating the required amount of radiation for the upper floors it was necessary to consider the effect of increased wind velocities, lower temperatures at the tower floors and building chimney action. On the 10th floor the amount of radiation installed is based on 1 sq. ft. for every 3 ft. of glass surface and 1 sq. ft. of radiation for every 10 sq. ft. of exposed wall. Twenty-five per cent is added to this for radiators on the north side of the building and 15 per cent for radiators on the south side of the building. To take care of the building stack effect on this floor 20 per cent has been added to the calculated radiation requirements. This percentage varies from 30 per cent on the lower floors to 10 per cent on the higher floors, and above the 20th floor

it has been omitted altogether. In the tower section the radiation has been calculated on the basis of a wind velocity of 25 miles per hour.

The returns from radiators above the 60th floor are collected in the 60th floor pipe space and return separately to the basement. Returns from the radiators between the 30th and 60th floors are collected in the 30th floor pipe space and also return direct to the basement. Returns from the radiators between the 30th and 17th floors join the returns from the lower 16 floors. Condensate meters have been installed to separately meter the returns from each of these sections. Three vacuum pumps, consisting of one duplex unit and one single unit have been installed to handle the heating system returns. During severe weather it is expected that two pumps will be required to take care of the heating load, but that subsequently only one pump will have to be operated. The pumps are arranged so that any one of them can be used as a spare. The heating system condensate is pumped through water pre-heaters before being discharged into the sewer.

Each of the distributing headers in the various pipe spaces have been divided into two sections, one covering the northwest exposure and the other covering the southeast exposure. Remote control, air operated valves have been installed so that steam to these sections can be turned on or off as conditions require. Thermometers, arranged to give indications at the engineer's office, have been installed at 28 locations inside the building, and also at 28 positions outside of the building. It is expected that these temperature indications will greatly aid the operation of the heating system and particularly it will tell the engineer when to turn the steam on in the morning.

Mr. Ralston touched upon some of the other mechanical features of the building which included 14 ventilating systems, the duct work of which is all of galvanized copper bearing steel. Alternating current is supplied throughout the building with 13,000 volt feeders run to distributing centers on various floors. Thirty-two passenger elevators have been provided, and those running to the tower have been designed for a maximum speed of 1,000 ft. per minute.

W. H. Driscoll expressed the opinion that the chimney action in buildings was very much overrated, and that its effect on the heating system should be considered only between the first and third floors.

Webster Talmadge gave a short illustrated talk on the reasons and necessity for zoning heating systems. He explained how zoning may be accomplished by the installation of orifice plates at the radiator inlets and that with such an installation the entire system can be controlled from a centrally located board in the chief engineer's office.

A. S. Armagnac, chairman of the program committee, introduced the speakers.

Pres. E. J. Ritchie opened the meeting and called upon R. Kuhlmann to talk about the membership campaign. Mr. Kuhlmann told the members about the national campaign being directed by C. W. Farrar, Buffalo, and told those present about some of the men who were eligible for society membership.

St. Louis

December 4, 1929: The St. Louis Chapter held its regular meeting at the Roosevelt Hotel, on December 4, 1929, with 16 members present.

After dinner President McMorran called the meeting to order, and the minutes of the last meeting were read and approved.

There being no reports from committee and no unfinished business, President McMorran read the report of the nominating committee who had nominated as follows:

President.....E. A. White
First Vice President.....C. G. Buder
Second Vice President.....R. M. Rosebrough
Treasurer.....A. L. Walter
Secretary.....Paul Sodemann

Board of Governors: F. J. McMorran, E. H. Quentin, L. Walter Moon, C. A. Pickett.

He then called for nominations from the floor and there being none proceeded with the ballot which was taken individually for each officer, in all cases being unanimously in favor of the candidate. After a brief speech in which he expressed his appreciation to the Chapter for the cooperation given him while President, Mr. McMorran turned the meeting over to the newly elected President, E. A. White. President White delivered a speech in which he stressed the necessity of getting into our membership those who are now in the city in the heating and ventilating business, and who are not members, as well as outlining his program for 1930 in a general way. He also permitted discussion of various matters from the floor. The newly elected officers each in turn said a few words.

There being no further business the meeting was adjourned at 9:30 p.m.

Philadelphia

November 14th, 1929: The November meeting of the Philadelphia Chapter was held on November 14, at the Midday Club, Fidelity-Philadelphia Building. After a very enjoyable dinner, which was served at 6:30 p. m., a short business session was held, with President Edgar acting as chairman.

The minutes of the October meeting were read by the Secretary, and approved.

The Treasurer's report was submitted by Mr. Sanbern, and approved without correction.

Mr. Blankin, Chairman of the Meetings Committee, gave a brief report on the various meetings to be held in the future, and called particular attention to the December meeting, which has been designated as Ladies Night, urging all members to attend and help make this special affair a complete success.

The meeting was then turned over to Mr. Morgan, Vice-President of the Fidelity-Philadelphia Building Corporation, who acted as toastmaster. Mr. Morgan called upon President Thornton Lewis, of the National Society, who gave a brief report on the recent visit of a special committee, appointed by the Society, to confer with U. S. Public Health Officials at Washington, in regard to a recent bulletin issued by the Department, relating to school ventilation.

John B. Lear, of the Fidelity-Philadelphia Building Corporation, gave a very interesting and instructive talk on Invisible Service in Office Building Management.

Edward P. Simon, Architect for the Fidelity-Philadelphia Building, then outlined briefly the various problems encountered in the construction of the building, calling particular attention to the co-operative spirit manifested by the various contractors supplying equipment for the building, which resulted in the structure being completed in an unusually short period of time.

A rising vote of thanks was extended the officials of the Fidelity-Philadelphia Building Corporation, particularly Mr. Morgan, Mr. Cheyney and Mr. Lear, for their courtesy and thoughtfulness in helping to make this meeting a complete success, and one to be remembered. The motion was unanimously carried.

This meeting was unquestionably one of the best the Chapter has had in recent years, having an attendance of 110 members, in addition to a number of guests and officials of the Fidelity-Philadelphia Corporation.

All business having been attended to, the meeting adjourned, after which an inspection of the building was conducted by representatives of the Fidelity-Philadelphia Building Corporation.

Wisconsin

December 9, 1929. On Monday evening, December 9, 1929, the members and guests of the Wisconsin Chapter of the Society met at the Elks' Club where they gathered for their regular monthly meeting.

H. W. Schmidt, who is supervisor of buildings of the State Department of Public Instruction at Madison, was the speaker of the evening. Mr. Schmidt gave an exceptionally interesting and well prepared talk on Field Experiences and Observations of Public School Heating and Ventilating Systems.

The attendance of members and guests was unusually good and the audience was keenly interested in the statements of the speaker and expressed its pleasure of the opportunity offered by extending a rising vote of thanks to the speaker.

November 18, 1929. The monthly meeting of the Wisconsin Chapter of the American Society of Heating and Ventilating Engineers held November 18, 1929, was opened by Pres. Fred G. Weimer, with an attendance of 38 members and guests.

Following a silent tribute paid to Edward Grassler, who had recently passed away, the president of the Society, Thornton Lewis, addressed the meeting on the subject of The Future of the A. S. H. V. E. In his introductory remarks he said that the Semi-Annual Meeting of the Society is to be held in Minneapolis. President Lewis also spoke of the organization of the Society 35 years ago, mentioning the importance of the Society, and urged the members to anticipate with the Membership Committee in bringing in new members.

The reasons for changing the method of publishing the Journal were also discussed by President Lewis, as well as the latest developments in the school ventilation controversy and the work done with the United States Public Health Service in the interest of mechanical ventilation.

C. W. Farrar, chairman of the Membership Committee, then spoke of the practically level progress of the Society in the matter of membership during the past three years and the need of new members now.

Mr. Farrar also explained that in addition to the individual prizes awarded to those bringing in the most members the Chapter securing the greatest per cent of new members is to be presented with a banner.

A short report on the progress of the Wisconsin Chapter membership drive was then given by Howard Haupt.

After a general discussion on new members, the meeting was adjourned.

October 21, 1929: A regular meeting of the Wisconsin Chapter was held on October 21, at the Elks Club, Milwaukee. A dinner was served at 6:30 p. m., after which the meeting was opened, with an attendance of 25 members and guests.

President Weimer, of the Chapter, announced the following Committee appointments for this year:

Membership: Howard Haupt, Chairman; A. Goethel, C H. Jackson.

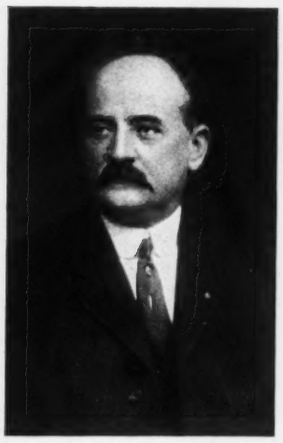
Picnic: Edward A. Knab, Chairman; John Jung, A. Freeman.

Entertainment: E. Szeckly, Chairman; E. A. Jones, C. Randolph.

A. V. Hutchinson, Secretary of the American Society of Heating and Ventilating Engineers, was then called upon and spoke of the future meetings of the A. S. H. V. E., the procedure of application for membership, resulting in either approval or rejection, and the qualifications required for various grades of membership. He explained the meaning of limited chapter memberships, and methods by which they are handled by other Chapters. For the benefit of those who never have attended a National Meeting, Mr. Hutchinson fully explained its procedure, as well as the type of meetings other Chapters held, and their method of conducting same. Mr. Hutchinson subsequently answered several questions regarding meetings. He also announced the coming visit of Pres. Thornton Lewis and C. W. Farrar at the November meeting.

There being no further business, the meeting was adjourned.

Death of Henry Adams



Word that Henry Adams, past-president of the Society, had died suddenly at his home in Baltimore, December 9, came to the membership as a great shock, for Mr. Adams was known as an outstanding member of the consulting profession, specializing in mechanical engineering.

While dining with his family at his home, 609 West 40th St., Baltimore, he was stricken and died before the arrival of his physician.

Mr. Adams was born February 11, 1858, at Duisburg, Germany, and studied technical engineering, as well as building engineering at Holzminden, Brunswick, and special studies at Aachen.

After practising his profession in Germany he came to Baltimore in 1880 and was associated with Bartlett and Hayward for four years, after which he became chief engineer in the office of the supervising architect for the Government, in charge of heating and ventilation of all Federal buildings. During his administration he established the mechanical department of the Bureau and remained in the Government service until 1898.

In Baltimore he opened his own office as a consulting engineer and since 1898 has supervised or designed the mechanical equipment in many of the city's largest buildings, as well as in outstanding buildings in other cities, such as the Union Medical College, Peiping, China, and the Masonic Temple in Manila, Philippine Islands.

At the time of his death Mr. Adams was president of the Maryland Institute, an association which began 45 years ago when he started as a teacher. For 12 years he held the teacher's position in the Institute and in 1902 became a member of the Board of Managers and later served as vice-president; in 1920, he was elected president.

During the World War Mr. Adams served as engineer with the U. S. Fuel Administration for the States of Maryland and Delaware.

Mr. Adams became a charter member of the A. S. H. & V. E. in 1895, and served as its president in 1899. He was very active in the establishment of the Society and contributed frequently to its technical literature.

During the years since he was president he has kept closely in touch with Society activities and has been a frequent attendant at Annual Meetings and was an honored member of that group who meets annually, the Past-Presidents of the A. S. H. & V. E.

In addition to his interest in heating and ventilating Mr. Adams was a member of several other technical organizations including the *American Society of Mechanical Engineers, American Water Works Association, Maryland Academy of Science, Munipical Art Society* of Baltimore and he was also active in Masonic and other fraternal organizations.

Besides his widow, Mr. Adams is survived by three sons.

The officers and Council of the Society feel very keenly the loss of so distinguished a member and extend to Mrs. Adams and her sons their heartfelt sympathy for the sudden loss that they have sustained.

To the Officers and Members
of the American Society of
Heating and Ventilating Engineers:

Cordial greetings are extended by the heating and ventilating equipment manufacturers of Philadelphia who desire to aid in making your visit to our city a memorable one.

A special invitation to visit the various nearby plants is given and the entire day, Monday, January 27, has been reserved for this purpose.

Philadelphia is proud of the part heating and ventilating plays in its industrial life and is especially glad of this opportunity to invite inspection of its plants by the Society's members.

December 20, 1929.

Brown Instrument Company
Frost Research Laboratory
John J. Nesbitt, Inc.
Schulte & Koerting Co.
Warren-Webster & Co.
York Heating & Ventilating Corp.

In the list of Candidates Elected to membership in the Society, published on page 695 in the December JOURNAL, it was not clearly indicated that J. W. Millard of the York Heating and Ventilating Corp., was district manager located at 410 Asylum St., Hartford, Conn.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the name of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 88 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibilty for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 5, 1930, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary, immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ADAMS, WILLIAM HERBERT, South Main St., Colchester, Conn.	Edwin C. Evans Samuel E. Dibble	
ANDERS, GEORGE W., Pres., Sterling Engrg. Co., Milwaukee, Wis.	V. A. Berghoefer R. G. Olson	F. G. Weimer A. C. Goethel
ANDERSON, SAMUEL WILSON, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen F. P. Anderson	J. I. Lyle L. L. Lewis
ARNOLDY, WILLIAM FRANK, N. E. Branch Mgr., Minneapolis-Honeywell Regulator Co. of Minneapolis, Boston, Mass.	A. Gale Schanze Alfred Kellogg	C. T. Flint J. W. Brinton
ASBURY, NORMAN B. G., Sales Engr., York Heating & Ventilating Corp., Philadelphia, Pa.	R. S. Arnold H. P. Gant	Thornton Lewis J. V. Cavileer
ATKINSON, KENNETH B., Research Engr., York Heating & Ventilating Corp., Bridgeport, Pa.	J. H. Holton D. E. French	D. Morgan Abel C. D. Graham
AXTHELM, FRED G., 648 N. Forest Ave., Webster Groves, Mo.	W. H. Halley A. L. Walters	C. G. Buder R. M. Rosebrough
BABBITT, WILLIAM D., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	

BARNARD, MILTON E., Sales Engr., York Heating & Ventilating Corp., Philadelphia, Pa.	R. S. Arnold H. P. Gant	Thornton Lewis J. V. Cavileer
BEATY, GUY M., JR., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
BEITZELL, ALBERT ERNEST, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen J. I. Lyle	L. L. Lewis W. H. Carrier
BRANDI, O. H., Manager, Carrier Lufttechnische Gesellschaft, Berlin, Germany.	Dr. A. Klein J. I. Lyle	E. T. Murphy L. L. Lewis
BROWN, WILLIAM MURRAY, Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
BUCKLEY, JOSEPH L., Carrier Engrg. Corp., Philadelphia, Pa.	W. G. Hillen P. L. Davidson	W. A. Bornemann A. P. Shanklin
BURKE, JAMES, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	M. S. Smith L. L. Lewis
CASPERD, HENRY W. H., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	J. I. Lyle L. L. Lewis
COX, HARRISON F., 243 Carroll St., Paterson, N. J.	C. H. Hall A. E. Bastedo	H. W. Fiedler D. H. Faulkner
CRAWFORD, JOHN HUMPHREY, JR., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen H. Worsham	J. I. Lyle M. S. Smith
CROUSE, WAYNE W., Contractor, Wayne Crouse Heating & Plumbing Co., Pittsburgh, Pa.	M. C. Gillett S. E. Dibble	C. W. Wheeler H. E. Digby
CUCCI, VICTOR J., Kimball & Cucci, New York, N. Y.	D. D. Kimball A. S. Lau	R. A. Wolff A. F. Hinrichsen
CUNNINGHAM, TOM N., Branch Mgr., Carrier Engrg. Corp., Dallas, Tex.	W. G. Hillen M. S. Smith	L. L. Lewis J. I. Lyle
DEPPE, FRED W., Dist. Sales Repr., 1823 Railway Exchange Bldg., St. Louis, Mo.	Alvin Eichler J. L. DeNeille	E. R. Barnes C. A. Pickett
EASTMAN, CARL B., Dist. Mgr., C. A. Dunham Co., Philadelphia, Pa.	S. H. Pennell L. C. Davidson	E. N. Sanbern A. C. Edgar
EDMONDS, ALBERT SIDNEY, JR., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	H. Coward L. L. Lewis
FARLEY, W. F., Mgr., Heating Dept., Crane Co., New York, N. Y.	W. A. Murphy J. R. Murphy	E. N. McDonnell J. K. Peacock
FAUST, FRANK H., General Electric Co., Fort Wayne, Ind.	H. A. Whitesel (*A.S.R.E.*) C. Morganthaler (*A. I. E. E.*)	J. L. Knight (*A.S.R.E.*) A. R. Stevenson, Jr. (*A.S.R.E.*)
FENN, CHARLES VAN ORDEN, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen Thornton Lewis	L. L. Lewis A. E. Stacey, Jr.
FOSTER, TILLMAN RICHARD, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen L. L. Lewis	E. T. Lyle J. I. Lyle
GAMMILL, OSCAR ELBRIDGE, JR., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	L. L. Lewis H. Worsham
GILMORE, LOUIS A., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
GIVELBER, SAMUEL H., Secy. & Mech. Engr., The Kahn & Co., Cleveland, Ohio.	W. C. Kammerer J. J. Mason	H. M. Nobis G. H. Morris
GRANSTON, RAY O., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
GRAVES, CLARENCE C., Sec'y-Treas., Graves & Graves, Inc., 3047 Sheffield Ave., Chicago, Ill. (*Advancement.*)	G. M. Getschow H. M. Hart	Ben Offen H. K. Lees
HARE, WILFRED ALMON, Manager, Stoker Div., Whitehead & Kales Co., River Rouge, Mich.	G. H. Giguere J. E. Degan	H. M. Stephen E. H. Clark
HEARD, JOHN A. E., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen S. L. Groom	H. Worsham A. E. Stacey, Jr.
HEIMBERGER, OSCAR WENGARD, The Griscom Russell Co., New York, N. Y.	R. C. Jones Joseph Price	L. E. Sebald K. B. Millett
HEROLD CHARLES W., Herold Plumbing & Heating Co., Kansas City, Mo. (*Advancement.*)	Carl Clegg Ernest Jones	Henry Nottberg F. F. Dodds
HILL, CHARLES E., Hoffman Specialty Co., Inc., Waterbury, Conn.	M. H. Bjerken E. J. Uhl	H. J. Sperzel A. J. Huch
HOYT, LEROY W., Genl. Supt., Richards & Jessup, Inc., Stamford, Conn.	D. H. Faulkner C. A. Miller	C. Strock T. M. Kellogg
ISRAEL, CHARLES HENRY, JR., Salesman, York Heating & Ventilating Corp., Philadelphia, Pa.	R. S. Arnold H. P. Gant	Thornton Lewis J. V. Cavileer

JALONACK, IRWIN G., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
JENS, JENS, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen J. I. Lyle	E. T. Lyle L. L. Lewis
JOHNSON, KENNETH E., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
JUNG, JOHN S., Htg. & Vtg. Contractor, 554 Layton Blvd., Milwaukee, Wis. (*Advancement.*)	H. M. Miller F. G. Weimer	
KALLOCH, PARKER C., JR., Pres., Fintube Radiator Co., Inc., Long Island City, N. Y.	T. J. O'Donnell W. J. Olvany	W. H. McKiever W. H. Driscoll
KEITH LEWIS HAYDEN, Sales Engr., York Heating & Ventilating Corp., Philadelphia, Pa.	D. Moulton P. C. Pocock	J. A. Carey J. N. Hirst
KEPPNER, HARRY W., Heating Contractor, 1310 South 56th Ave., Cicero, Ill.	W. T. Walters J. C. Matchett	L. J. Pitcher Homer Linn
KLEINE, ROBERT E., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
LABOV, MILTON, Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
LANDERS, JOHN J., Sales Engr., U. S. Radiator Corp., Buffalo, N. Y. (*Advancement*)	H. F. Hutzel L. G. Gauvin	R. J. Moran C. W. Farrar
LILLARD, WALTER S., Plbg. & Htg. Contractor, Peru, Ind.	H. A. Thrush J. W. Pyle	R. G. Denk O. F. Rhodes
MACDONALD, DONALD B., Branch Sales Mgr., C. A. Dunham Co., Kingston, Pa.	J. P. Gilboy M. G. Hook	A. H. Hills G. E. Grill
MANN, ARTHUR R., Owner, Mann & Co., Archts. & Engrs., Hutchinson, Kans.	B. Natkin Sidney Pines	E. Haas, Jr.
MANNEN, HENRY C., JR., Walworth Co., Detroit, Mich.	G. H. Giguere H. C. Kappler	W. A. Blessed E. H. Clark
MARSH, ARTHUR BLISS, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	H. Worsham L. L. Lewis
MCCOY CLAUDE E., Genl. Supt., Eldorado Plbg. & Htg. Co., Little Rock, Ark.	Paul Sodemann R. K. Landreth	C. M. Baumgardner J. F. Hale
MEIER, CLEMENS F., Smith, Hinchman & Grylls, 800 Marquette Bldg., Detroit, Mich.	G. H. Giguere H. C. Kappler	W. A. Blessed H. M. Stephen
MICHIE, D. FRASER, Crane, Ltd., Winnipeg, Manitoba, Canada.	M. H. Bjerken A. M. Wagner	A. L. Sanford
MITCHELL, ANDREW JACKSON, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen J. I. Lyle	L. L. Lewis H. Worsham
MONROE, RAYMOND R., Nash Engrg. Co., South Norwalk, Conn.	H. M. Wylie I. C. Jennings	E. A. Mead A. D. Harvey
MORRILL, FRANK BAXTER, Engr., Buck Dryer Corp., New York, N. Y.	Lucien Buck H. B. Hedges	E. J. Ritchie E. B. Johnson
MORRIS, JACK BRUCE, John E. Green, Detroit, Mich.	G. H. Giguere J. E. Green	B. J. Doyle E. S. Donahue
MUELLER, HARALD CHARLES, Sales Engr., The Powers Regulator Co., Chicago, Ill.	W. P. McFarland E. W. Rietz	C. W. Johnson J. C. Hornung
NEFF, CHARLES J., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
OLSEN, GUSTAV E., Mgr. of Sales, Fitzgibbons Boiler Co., Inc., New York, N. Y.	Raymond Newcomb Esten Bolling	H. B. Hedges J. A. Darts
PENDLETON, MORRIS E., Dist. Mgr., Armstrong Cork & Insulation Co., Buffalo, N. Y.	M. S. Jackson H. P. Dempsey	L. A. Harding E. E. Johnson
PETERSON, CLARENCE O., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
PETTIT, E. N., JR., Carnegie Inst. Tech., Pittsburgh, Pa.	Edwin C. Evans Samuel E. Dibble	
POHLE, KENNETH F., Dist. Mgr., W. F. Hirschmann Co., Inc., Boston, Mass.	W. F. Hirschmann J. Albert Reardon	C. W. Kimball R. E. Barton
PRICE, LEWIS C., L. C. Price & Co., 136 Federal St., Boston, Mass.	J. F. Tuttle W. P. Mower	E. W. Smallman C. R. Matthews
RAISLER, ROBERT K., Raisler Heating Co., 173 Riverside Drive, New York, N. Y.	L. K. Berman Samuel Raisler	F. C. Fay F. F. Taverna
RENTE, SIDNEY R., Sales Engr., Crane Co., Buffalo, N. Y.	Joseph Davis A. K. Tinker	D. J. Mahoney F. H. Burke
REX, HARLAND E., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen G. L. Larson	W. H. Carrier J. I. Lyle
RISER, SPENCER P., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	L. L. Lewis M. S. Smith

ROLLINS, LEONARD EUGENE, Designer, Smith, Hinchman & Grylls, Detroit, Mich.	G. H. Giguere L. L. Smith	George Mehring H. M. Stephen
SCHAFER, HARRY C., Dist. Sales Mgr., B-Line Gas Boiler Co., Cleveland, Ohio; Skinner Bros. Mfg. Co., Inc., St. Louis, Mo.; Mears-Kane-Ofeldt, Inc., Philadelphia, Pa.	F. H. Burke C. A. Evans	C. W. Farrar O. K. Dyer
SCHUENGEL, GEORGE W., Sales Engr., N. Y. Blower Co., Chicago, Ill.	H. Mathis H. F. Maier	H. M. Shufelt H. H. Davis
SCOTT, LESLIE O., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen L. H. Polderman	J. I. Lyle L. L. Lewis
SHARPE, NORMAN, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	L. H. Polderman J. I. Lyle
SHIELDS, MORTON KINGMAN, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen J. I. Lyle	L. L. Lewis A. E. Stacey, Jr.
SNELLING, LOUIS R., Manager, National Radiator Corp., Buffalo, N. Y.	A. K. Tinker Joseph Davis	F. H. Burke O. K. Dyer
STEWART, DUNCAN J., Experimental Engr., Barber-Colman Co., Rockford, Ill.	G. L. Larson D. W. Nelson	W. M. Richtmann
SZOMBATHY, LOUIS R., Pres., Ferguson Sheet Metal Wks., Inc., Ferguson, Mo.	W. H. Halley A. L. Walters	C. G. Buder R. M. Rosebrough
TAYLOR, KENNETH A., York Heating & Ventilating Corp., Philadelphia, Pa.	H. P. Gant Donald French	J. V. Cavileer R. R. Taliaferro
TURNER, JOHN, Sales Engr., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.	A. Gale Schanze Alfred Kellogg	C. T. Flint J. W. Brinton
WELDY, LLOYD O., Powers Regulator Co., Chicago, Ill.	W. P. McFarland E. W. Rietz	C. W. Johnson J. C. Hornung
WILLIAMS, LEO ERNEST, Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	A. E. Stacey, Jr. N. S. Smith
ZELLWAGER, LOUIS S., Carrier Engrg. Corp., Newark, N. J.	W. G. Hillen W. H. Carrier	L. L. Lewis A. E. Stacey, Jr.

Candidates Elected January, 1930

In past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BEAVERS, GEORGE ROBERT, Canadian Blower & Forge Co., Woodside Park, Kitchener, Ont., Canada.

HARD, ALVA L., Freyn Brothers, Detroit, Mich.

HEIM, E. FRANK, Consulting Engineer, 1800 E St., N. W., Washington, D. C.

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Heating · Piping
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EDITORIALS

Elimination of Waste

When business comes easy and competition is not so keen, we are not so much interested in elimination of waste. And it may provide some insight into our business structure to record here the fact that the United States of America, reputed to be the most wasteful nation in the world, has organized in the field of engineering an elimination-of-waste campaign which, in less than a year, has become international in scope.

Early last year, an elimination of waste committee, sponsored by the management division of the *American Society of Mechanical Engineers* and the *American Management Association,* started to work together in meetings (another of which will be held in Chicago early in 1930) to co-ordinate this rapidly growing, elimination-of-waste movement.

Industrial plants, office buildings, hospitals, schools, churches, garages, apartment buildings, hotels, etc. sometimes continue for years wasting fuel and labor having, in the mean-time, no clear conception of a method or procedure for discovering the extent of these wastes or how they can be avoided. Waste is so common that it has developed a class of engineers who are willing to undertake the elimination of waste for a percentage of the savings.

Steam leaks, water leaks, air leaks, failure to balance steam pressure with the requirements, failure to consider the critical night temperature, lower or higher than which the building can not be maintained without waste of fuel,—these are common practices and are typical of hundreds of other wasteful operations that are found wherever piping, heating and air conditioning equipment is used. It would be difficult to measure the enormous savings that would result from the wide application of methods for elimination of waste in heating and air conditioning that recently have been employed by one chief operating engineer of a certain group of office and apartment buildings in Chicago.

Why, for instance, should the heating of an office building cost 10 per cent more for 250 degree days in 1928 than in 1929? It would seem evident that there is a waste somewhere. With two office buildings, similar in cubic capacity, structure, and location, why should one require 25 per cent more fuel than the other for a heating season? Was it the fireman, the fuel, or the equipment that was at fault? When the cost of operation of air conditioning equipment is $1.00 per year per occupant in one building and $1.60 per year per occupant in another building, what are the factors that are responsible for this difference in cost? Studies of cost of operation and maintenance of heating, piping and air conditioning equipment doubtless will be given an impetus by this elimination-of-waste movement which already has led several concerns to discover avoidable wastes of from 6 to 72 per cent.

Keeping Modern

Mechanical improvement in the last few years has increased in a manner comparable to that of the increase of velocity of a falling body. In air conditioning, for instance, it is stated that there has been more progress in the last ten years than in all of its previous history. Keeping modern is more difficult than it ever was before. Pre-eminence and even prominence in most fields is maintained these days only by constant improvement. Business concerns are looking more than ever to research to forestall or prevent depressions and crises. Keeping modern is the unwritten law of survival.

Death by Dust

According to Stuart Chase, in his "Men and Machines," an analysis of death rates in England, made according to occupations, showed that workers exposed to large quantities of dust died at a rate 200 per cent of the average of all the groups studied. Such occupations as file makers, tin miners, etc., were included in this "dust group."

According to this survey, dust ranks second (in order of danger) as an industrial hazard. Alcohol (the survey was made in England) topped the list, bar-men having a death-rate greater than 200 per cent of the average of all.

It would seem that even though there were no great improvements to be made in dust collecting and eliminating devices, there is certainly room for a much more general use of this equipment. The elimination of dust and dirt is an important phase of air conditioning. The advantages to be gained range all the way from the removal of a petty an-

noyance to the lowering of the national death-rate.

The removal of an objectional condition, according to many, should be made at the source. Where this is impossible, air conditioning must come to the rescue. It is equipped to do so, and should be given a greater opportunity.

Engineers in a New Role

The nations of the world are attaining new levels of economic progress largely through wider use of the knowledge and equipment of the engineer. Recently the Russian government sent to this country for an expert on refrigeration and cold storage of meat products. An American engineer was sought for his services in connection with the mechanical equipment of a large hospital in Manchuria. The work of the engineer is seen in the largest quick freezing storage warehouse in Canada and in making the Dead Sea in Palestine give up its wealth of chemical products. One finds engineers developing new enterprises on the Nile river, in Spain, in the Alps of Switzerland, in Austria and Germany, in South America, in Tibet and probably in every country in the world.

The most obvious product in most of these engineering projects is piping. The equipment may vary but the piping is seen everywhere,—piping for steam, air, water, oil, gas, drugs, chemicals, liquids and semi-liquids that are made into manufactured products.

This world-wide use of piping necessitates a common basis upon which technical and engineering developments may proceed unhindered by differences in practice. This is being met by the establishment of world engineering conferences. Such a conference was held in London in 1924. A world engineering congress which was attended by a number of readers of this publication was held in Tokio during the fall of 1929. A world power conference will be held in Berlin in 1930.

We have grown accustomed to an active international movement of capital unprecedented in the history of the world. But this is growing to mean, to a greater degree than ever before, an interchange of engineering knowledge and personnel. At a time when ways and means of avoiding wars are being sought under the leadership of the world's statesmen, credit should be given to the engineer, who, by correcting the inequality of economic conditions, is one of the most potent factors in removing causes of friction between nations.

Among manufactured products, piping stands high in its ability to promote peace and prosperity.

The Printer and Air Conditioning

For a number of years almost every conceivable facility had been placed within the grasp of the printer except control of weather. But leading printers are now controlling air conditions in the plants and the facts regarding this essential to good printing recently were broadcast to printers throughout the world during the World Conference of Printing Industries.

Color has invaded almost every industry and printing is no exception. Those who buy printing demand color. The key color is run, say, on Monday in weather of 35 per cent relative humidity. On Tuesday another color is run in a relative humidity of 65 per cent. The printer then finds to his consternation that the grain dimension of his sheet of paper has lengthened. If he takes the trouble to make a close investigation he will find that for coated paper the increase is about ⅛ inch on a 32-inch sheet. The result is that the two colors do not match. They are "off register" as the printer terms it.

Low humidity in winter is accompanied by static which causes the sheets to stick together. On this account it is at times impossible to use an automatic feeder. Because of the tendency of the sheets to stick together, slip sheeting becomes necessary. These are typical of the troubles of the printer due to unfavorable weather conditions.

Some printing experts state that humidity control has done more than anything else to improve the uniformity and quality of their printing work. This statement could well be applied to practically every industry.

An Advertising Medium

In distributing the costs of air conditioning for the J. L. Hudson Co. store at Detroit, the cost for the main floor is charged to advertising. "We realize" they say "that if we can make our patrons comfortable and draw them off the street the equipment will soon pay for itself in the advertising and the additional sales which will result." So it appears that another industry, just as the theaters have done, has discovered the practical, commercial value of air conditioning.

But this is only the beginning of the possibilities of air conditioning as a means of advertising. It will enhance the value when it is known that a certain brand of shoes, for instance, is made under healthful atmospheric conditions. The public unconsciously will sense the fact that a manufacturer who is concerned about the health of his employes is also concerned about the inherent quality of his footwear.

The manager of the office building knows that the public will more readily enter the building that has healthful and pleasing atmospheric conditions than a building in which those conditions are absent and here again pleasing and healthful atmospheric conditions will have an advertising value. The office renter knows that his patrons will sense in his air conditioned office something that is superior to that in offices that are not air conditioned, and, by analogy, the patron will conclude that the service rendered or the products marketed from the air conditioned offices will be superior to those rendered or marketed from the offices where these conditions are lacking.

INTERVIEWS OF INTEREST

The National Capitol

An official report in the January, 1930, issue of Naval Medical Bulletin made by George W. Calver, commander, Medical Corps, United States Navy, on the air conditioning installation recently made in the Senate Chamber and the Hall of the House of Representatives gives the equipment relationships of the several units of the system and discusses the actual room air conditions as to currents, rates, diffusion, variability, and the like along with medical correlations that are being built up on the basis of consistent record.

The report is an interesting historical document which traces the very casual consideration of ventilation matters in the early construction plans for additions to the Capitol in 1850, through controversial periods that were quite acrimonious at times, but for the most part without much effort to remedy conditions of drafts, dust, odors, dead-air pockets, and short-circuiting of currents until the rather extensive repairs instituted under the regime of Mr. S. H. Woodbridge. Almost the whole history of mechanical ventilation can be read between the lines of Dr. Calver's report.

Read in connection with the hearings of the House Committee on Appropriations of the 70th Congress, first session, 1928, pp. 128-176, which preceded authorization of the project, one gains some appreciation of what a patient process it is to effect any radical building improvement, and what may be looked for in the way of obstacles.

Dr. Calver discussed with us the precision features of control that pertain both to installation and operation features of the new plant, and the meanings of the elaborate care he is taking to correlate the air environment conditions with data on health. Dr. Calver said:

"This first report in the main is historical. It seemed desirable to describe at the outset the developmental course of the idea. The confusion of personal predilection, technical controversy, and interest alignment; the piece-meal repairs that represented compromise, not solution of trying difficulties, are only slightly more wavering than other projects that are less in the public eye.

"In view of the many-sidedness of the hygienic considerations involved, it is not surprising that preliminary hearings on this subject before the Appropriations Committee parried all questions on specific relationships to health. They limited their data to physical findings in the old plant, such as over-heat and dryness of the air in winter, excessive humidity and lack of cooling power in summer, dust, and dead-air pockets. Their recommendations called for a plant capable in summer of maintaining during maximum occupancy 'a temperature not in excess of 75 deg fahr., with a relative humidity not in excess of 55 per cent, with outside weather conditions of 95 deg. dry bulb and 75 deg. wet bulb; and, in winter, a temperature up to 75 deg. with a relative humidity of 30 to 50 per cent; these conditions to be maintained without noticeable draft and without noticeable odors in any part of either chamber, as measured by a variation in CO_2 content in excess of 4 parts per 10,000 between different parts of the chamber.'

"Actual physical demonstration of satisfactory air conditions within the chambers was to be taken as the criterion of efficiency. The presence of bacteria did not count, for a plant capable of carrying the load specified would take care of bacterial contamination adequately.

"What actually transpired was that the outworn, inadequate, controversial plant has been replaced by a system which operates in seven separate but inter-related units to deliver filtered, washed, refrigerated, and otherwise conditioned air to floors, galleries, cloak rooms, press rooms and corridors of the Congressional chambers. The zone occupied by members of the House receives 36,000 cubic feet per minute. The floor of the Senate receives 18,000 cubic feet per minute with 36,000 cubic feet to galleries and accessory rooms.

"Operating conditions (set with due regard for the age groups served) result in air delivery ranging around 72.5 deg. fahr. with relative humidity in the neighborhood of 50 per cent. Air is cooled in summer to a point about 7 deg. cooler than outside temperature, and dehumidified to 50 per cent or less. Automatic regulation is on the basis of continuous automatic electric records at 16 different points within the plant and in the chambers.

"After several important and highly detailed adjustments of plant had been made to meet certain conditions of operation, chiefly relating to reduction of openings in exhaust ducts, a gradual movement of air and good diffusion without draft was achieved, with air change approximating every five minutes.

Bacterial Counts

"Under new conditions, repeated bacterial counts at twenty-two different stations in the House have shown 50 per cent reduction over the studies made in 1924 that counted so largely in the preliminary hearings. Moreover, it is believed due to oxygenation, the bacterial count of the wash water in the system is less after some hours of use than after a period of disuse.

"The findings with respect to inorganic dust are not so clear cut. Molds, for instance, increase in the wash water and spores of molds are proved by culture of air after it leaves the machines. Operative conditions have been set, therefore, requiring that wash water be changed after one hundred hours of operation. Cultures have been taken of nine types of mold.

"Kata thermometer readings are made frequently to check against the possibility of any serious variations, and we are adapting our apparatus and technique for better precision in humidity readings and in measurement of air currents within the rooms.

Comfort Conditions

"Comfort conditions are much better than of old. Members state that they now sit through full-day ses-

sions without the headaches and depression they formerly suffered.

"The hygienist has had to be extremely tentative in any statement made with respect to air environment and health. Such health correlations as have seemed significant are usually open to criticism for want of adequate engineering record or because diagnostic data were lacking to support the hygienic argument.

"We have here a well-defined age group of similar pursuits, medically well-supervised, and conditions fairly constant with continuous, dependable record on all critical matters and full check by individual, repeated readings on the part of a technical staff fully competent over sufficiently prolonged periods to justify positive conclusions. Also, the medical component of the inquiry will have the benefit of full co-operation from Mr. A. E. Stacey, Jr., field engineer of the contractors, and Mr. David Lynn, architect of the Capitol. The competence of the engineers in charge of the plant is unquestioned. The set-up is distinctly one of promise and we should collect much data of scientific value."

New York Architect Discusses Windowless Buildings

Robert D. Kohn, architect of New York City, is designer with Charles Butler and Clarence Stein of Temple Emanu-El, the third largest religious edifice in the United States and the largest Jewish temple in the world. The equipment of this edifice for mechanical ventilation will command our especial attention later.

Mr. Kohn's office building projects are progressively, even daringly, carried out in their engineering aspects. He never falters at a new scheme simply because such solution of an engineering problem has never been put through before.

Mr. Kohn has met the problem of city noise and dirt in a highly versatile manner, with full recognition that the exigencies of modern architecture carry a challenge to engineering science also.

Mr. Kohn recently declared that it is not at all a wild assumption that city structures of various types will be built with solid walls, entirely without windows. "When Rudolph Miller made a similar declaration last year before the conference on steel construction of the American Institute of Architects, the public gasped and the press played elaborately with the idea as if it were an absurd and groundless fancy on the part of over-specialized engineers.

"Nevertheless, I have before me now an extensive office building project in which the light, heat, and ventilation all are artificial. This project involves the construction of a group of executive offices for an important corporation so arranged that they will be in the middle of a large floor area entirely removed from windows.

"This condition has been stipulated by the general manager of the corporation concerned, who said that it is quite impossible to continue handling executive work near windows as at present because of noise and dirt.

"The scheme in this case is relatively simple for only last year the building was equipped with the largest air-cooling plant of any large mercantile building in New York City.

"The idea is not revolutionary. New York City theaters, auditoriums, and lecture rooms are all artificially handled with respect to light, heat and air.

"The idea is not new. It was as far back as fifteen years ago that I built my first assembly hall without any windows at all on the principal street. Moreover, in this same project the windows on the side street are of double glass, without any opening parts. The windows are not for light or air. They are an integral part of the design, and are there merely for decoration.

"The scheme was adopted mainly to exclude noise. It has become almost an axiom that any kind of auditorium or conference hall for public use should be built today, like theaters, without windows."

Problems in Central Heating

The economies of central heating, as against the practice of making every separate building a self-contained unit on all heating, and other engineering services, were discussed for us recently by George O. Vonnerta, technical adviser, office of the supervising architect, Treasury Department, Washington, D. C. Working under Major Ferry K. Heath, Mr. Vonnerta has been concerned in recent conferences in Washington on heating plant problems of public buildings both in Washington and throughout the country.

"As far back as ten or fifteen years ago," states Mr. Vonnerta, "a number of tunnels were constructed in Washington looking toward central heating plants as soon as such service could be installed. Central heating now constitutes one of the most insistent problems for practical solution.

"But there are many difficulties to be overcome. It was proposed that the building development of the triangle in Washington would be served by a great central plant located on the water front near by; but objection was made that plans for civic improvement of that district would interfere. Another location for such a plant is now being sought for.

"There is the further hampering consideration that, although extensive plans for the triangle improvement have been accepted, the work is only one-third authorized.

"Pending final decision on these matters, the heating plants for housing projects now under construction are somewhat cheaper than would otherwise be feasible. These plants in a sense are temporary, but they are always capable of conversion into 'breakdown' plants or can be maintained for emergency.

"These matters have been subjected to practical test in Washington. Three big central heating plants are now in operation. One plant takes care of the legislative group of buildings. Another plant, located in the State, War, and Navy Building serves this building, the White House, and some other buildings. A third big plant, the last central plant to be erected, is located near Nineteenth and B Streets. It heats what is known as the Potomac group of buildings.

"Outside of Washington the Government has employed central heating in only a few large centers, as New York, San Francisco, and others. Consideration of central heating in such cases always calls for careful comparisons of costs. In many cases it is cheaper to buy heat than to produce it, but even so we have always provided government buildings with their own plants. It has been a necessary emergency provision. Also, it reduces any possibility of costs mounting year by year as might be the case if entire dependence were placed upon heat that had to be contracted for."

Ventilation of Federal Buildings

Nelson S. Thompson, superintendent of mechanical engineering, division of the office of the supervising architect, Treasury Department, Washington, D. C., discusses for us many building operations under way and projected in the huge housing program of the United States Government at Washington and in post office and other Federal buildings of the country.

"Many pressing problems in ventilation come up for consideration both in new construction and remodelling work," he says: "In offices and other quarters where space allotment is relatively generous or population density small, ventilation is satisfactorily accomplished by means of windows. Court rooms always require mechanical aids for air change. Post office rooms in basements depend upon fans. Unit ventilation is frequently the best solution of ventilation problems in sequestered sections and in older buildings.

"The trend during the past twenty-five years has been definitely away from the ventilation of *all* spaces within a Federal building. Buildings now are zoned, and ventilation is installed in strict accord with the purposes to which each zone is to serve. Heating is planned throughout, but air supply relates to specific service of occupancy requirements. Windows, unit ventilation, central systems—all come into play by turns.

"The old guess work on which to base ventilation design has been superseded by very close calculation. Time was when any structure that housed four or five fans and had been made to carry seven or eight carloads of sheet iron was rated as a ventilated building. Now we know better. Modern ventilation data discount such practice. Modern control develops precision work.

"Precision also removes the moral hazard of overloading a job with equipment. The system is all wrong that pays the technical service of an engineer on percentage bases of equipment used, in my opinion.

"Mechanical equipment costs of the United States Government housing projects average from 5 to 6 per cent of cost of buildings (exclusive of land) for heat, light, and air. Twelve per cent, exclusive of land costs, includes these features and also the elevators and plumbing. The Internal Revenue Building involved 10 per cent of building costs for these mechanical services.

"Ventilation means the introduction and removal of air. A building is not ventilated except as air change and air control can be physically demonstrated. Long range economies require a suitable consideration of maintenance costs along with installation charges. Strictly speaking, ventilation discomfort merely reflects excess heat. The engineer should govern his plans accordingly."—S. P. M.

An Easily-made Pipe Bender

Not long ago, a gas company in the southwest faced the problem of making a number of bends in short pieces of 2-in. pipe. The foreman of the plant designed and built for emergency use with the aid of the oxy-acetylene process, the pipe bending machine detailed in Fig. 4 and shown in operation in Fig. 1.

A piece of 12-in. pipe for an anchor post was set in concrete in a vertical position. The upper edge of the 12-in. pipe was swaged from 12 to 4 inches. A piece of 4-in. pipe was welded in the end. A 16¼-in. sheave was then secured and fitted into a yoke which, in turn, carried a 6-in. idler sheave, as shown in Fig. 4. The yoke was cut from 5/16-in. boiler plate and placed over the anchor post in such a way that it was free to revolve about the 4-in. pipe at the top. Two or three holes were then cut through the butt of the large sheave into the 4-in. pipe and then filled by bronze-welding, thus securing the 16-in. sheave tight to the post as indicated in Fig. 4.

The short piece of 4-in. pipe on the outer end of the yoke, shown in Fig. 4, is a socket for a bar, giving the required leverage. A ½-in. rod was welded around the rim of the fixed sheave as a clevis or brace to hold the end of the pipe which was to be bent, as shown in Fig. 1.

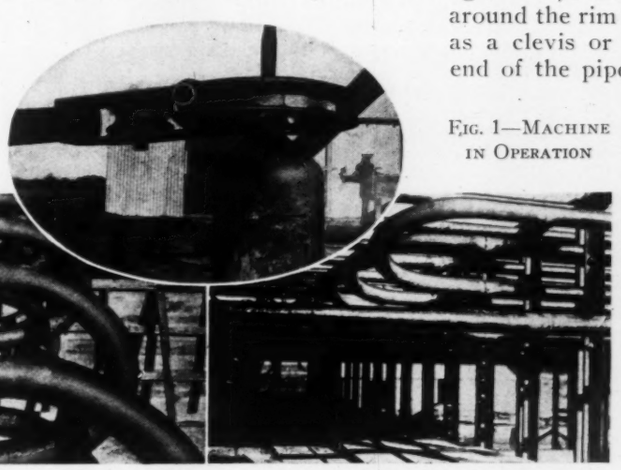


Fig. 1—Machine in Operation

When the machine was placed in operation, it functioned satisfactorily. The pipes to be bent were first heated to a cherry red with the blowpipe flame, and one end was inserted between the two sheaves,

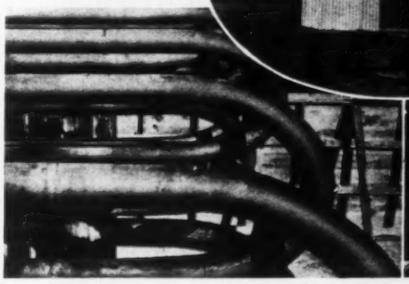


Fig. 2—Perfect Curves

Fig. 3—Uniformity of Welded Bends

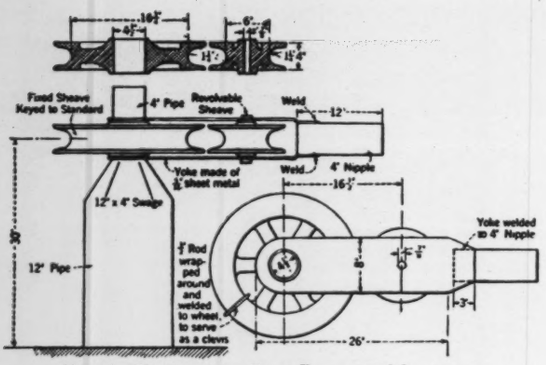


FIG. 4—DESIGN FOR PIPE BENDING MACHINE

and just through the clevis. The operator, by pushing on the bar, simply wrapped the pipe around the fixed sheave. Four men made 51 bends in 2-in. 1,800-lb. test pipe without a single failure. Figs. 2 and 3 show some of the return bends.

Ventilating and Heating Features of the Building Code of the Pacific Coast Building Officials Conference

THE EDITOR:

Please inform me what the heating and ventilating requirements are in the uniform building code of the Pacific Coast Officials Conference.—A SUBSCRIBER.

This code requires that every building more than two stories in height (excepting dwellings) shall have all stairways, elevator shafts and other vertical openings entirely enclosed with fire-resistive partitions, and that all openings into such vertical enclosures be equipped with self-closing fire-resistive doors. This, of course, makes each floor in the building a separate unit and does not permit the heat to pass from one floor to another without special ducts or other distributing system.

General Ventilating Requirements

The general ventilating requirements are covered by a clause as follows:

"All portions of buildings customarily used by human beings shall be provided with light and ventilation by means of windows and/or skylights with an area equal to one-eighth (⅛) of the total floor area or shall be provided with artificial light and mechanically operated ventilating system. The mechanically-driven ventilating system shall provide at least thirty (30) cubic feet of pure air per minute for each occupant thereof in all portions of the building and such system shall be kept continuously in operation during such time as the building is occupied."

There are other particular ventilating requirements covering specific conditions such as are found in public garages, dry cleaning plants, motion picture machine booths and stage areas. These requirements are quoted as follows:

Garage Ventilation

"In all buildings used for the storing or handling of automobiles operated under their own power and in all buildings where inflammable liquids are used, exhaust ventilation shall be provided sufficient to produce one complete change of air every fifteen (15) minutes. Such exhaust ventilation shall be taken from a point at or near the floor level."

Dry Cleaning Plants

"In dry cleaning establishments the walls of the cleaning rooms or room in which volatile inflammable liquids are used shall have vent holes at the floor line not less than sixteen (16) square inches in area placed not more than sixteen (16) feet apart at or near the floor line, properly protected by iron bars or screens; or such rooms may be equipped with exhaust ventilation sufficient to cause a complete change of air four times an hour with exhaust duct openings located at or near the floor line."

Motion Picture Machine Booths

"Every booth shall be equipped with a ventilating inlet not less than thirty (30) square inches in area, placed near the floor on each of three sides and protected by wire netting. At the top of every booth there shall be at least a ten-(10) inch diameter vent for each motion picture machine. Such vent shall be constructed of sheet metal not less than twenty-four (24) U. S. gage and shall connect into a masonry flue or go directly through the roof and twelve (12) inches above, and shall be provided with an exhaust fan that will produce a complete change of air in the booth every ten (10) minutes. No wood or other combustible material shall be allowed to come within four (4) inches of the vent. There shall be not more than one elbow or change in direction of this metal vent in any attic space. No such vent shall pass through any occupied room unless encased in not less than four (4) inches of solid masonry."

Stage Ventilators

"There shall be one or more ventilators constructed of metal or other incombustible material near the center and above the highest part of the stage of every theater, raised above the stage roof and having a total ventilating area equal to at least ten (10) per cent of the floor area within the stage walls."

The additional features covering stage ventilators provide for manual and emergency operation, specify that wired glass or plain glass with protecting screens must be used, and that the design shall be such that the operation will be positive and sure at all times.

An additional feature which may be interesting is the fact that the code limits the use of warm air furnaces to the heating of buildings three stories or less in height. Also, an air supply must be provided for every gas furnace, and such air supply shall lead directly to the outer air. It may be taken from the inside of the building, or may be a combination of both inside and outside air.

There are other features which regulate the installation and operation of all types of heating equipment, together with the construction of vents, chimneys and smokestacks which may be a part of such installations.

A bulletin of the Pacific Coast Building Officials Conference stated in July, 1929, that their uniform building code had been adopted by 55 cities in California, Oregon, Louisiana, Arizona, Washington, Arkansas and North Dakota. It was expected that many other western cities would adopt this code in the succeeding months.

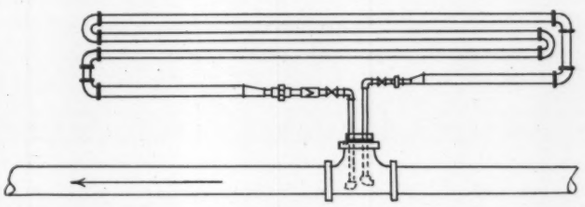
PRACTICAL PIPING PROBLEMS

A Steam Heating Coil Vacuum Cleaner for Railway Cars Clean Compressed Air

by **W. H. WILSON**

Steam Heating Coil Connections

The accompanying sketch shows a steam heating coil connection that has given satisfactory service for several years. Connections were made in this manner for the following reasons.



A Steam Heating Coil. Steam Line, 2½ In. Coil, 1½ In. Pipe Connections, ½ In.

The place to be heated was a small booth or enclosure that was situated near a 2½ in. pipe line carrying 110 pounds steam pressure. No return lines were near this location and for several reasons it was not desired to install a steam trap on the return end of the heating coil and permit the condensation to escape to the atmosphere.

Taking advantage of a tee in this line, near the location, with a full-size side opening, a plug was made with two ½-in. tappings and nipples were used that extended through into the interior of the pipe line. A street ell, with as much of the threaded end cut off as would permit it to pass through the side opening of the tee, was used on each nipple, and both were cut off enough to allow the whole assembly clearance when the plug with the nipples was made up. Care was taken to see that the elbow opening for the feed nipple was set directly facing the flow of the steam and the elbow on the return nipple was set directly against the flow of the steam.

The heating coil was made of 1½-in. pipe and contained 20 square feet of heating surface. Valves were placed on both the feed and return. A check valve was also placed on the return connection to prevent a possible back flow. Reducers were used to connect to the 1½-inch pipe. No trouble was experienced with this heating coil from air binding.

Cleaning Railway Cars

The sketch shows a device made from pipe fittings that is used in connection with compressed air for cleaning railway passanger cars.

The nozzle is made by taking a piece of ½-in. extra strong pipe with a long thread on one end to allow for adjustment of the proper distance past the side opening in the Y-fitting. The other end is tapered to a small opening, usually about ¼ in. in diameter.

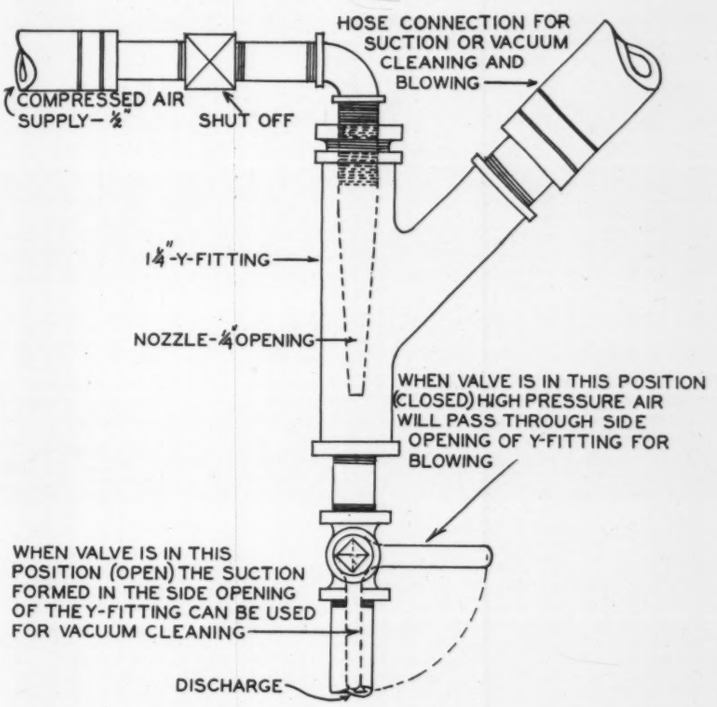
When in operation, with the stop cock on the discharge in the open position, air will pass through the nozzle at a high velocity and form a vacuum in the suction hose connection in the side opening of the Y-fitting, which is used for cleaning.

When the stop cock is closed, air will pass through the nozzle and back through the side opening of the Y-fitting. In this way, the device can be used for blowing and removing dust that cannot be picked up by the vacuum. When using this blowing connection, a suitable nozzle should be attached to the end of the hose to get good results.

The size of the pipe fittings and hose connections may be varied to suit the working conditions and a self-closing lever operated spring valve on the air supply may be found convenient in many cases.

Insuring Cleanliness of Compressed Air

Two of the several uses for compressed air in a modern cigar factory, are the supplying of approximately ¼ cu. ft. per minute at 50 lb. gage pressure to the auto-


HOSE CONNECTION FOR SUCTION OR VACUUM CLEANING AND BLOWING
COMPRESSED AIR SUPPLY– ½"
SHUT OFF
1¼"-Y-FITTING
NOZZLE-¼" OPENING
WHEN VALVE IS IN THIS POSITION (CLOSED) HIGH PRESSURE AIR WILL PASS THROUGH SIDE OPENING OF Y-FITTING FOR BLOWING
WHEN VALVE IS IN THIS POSITION (OPEN) THE SUCTION FORMED IN THE SIDE OPENING OF THE Y-FITTING CAN BE USED FOR VACUUM CLEANING
DISCHARGE

The Device Shown in This Sketch Is Used for Vacuum Cleaning Railway Passenger Cars. The Size of the Pipe Fittings May Be Varied to Suit Working Conditions